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CHARLES W. PRICE . . . . . PRESIDENT AND EDITOR
STEPHEN H. GODDARD . . . . . SECRETARY AND MANAGER
WM. HAND BROWNE, JR. . . . . TECHNICAL EDITOR
AINSLIE A. GRAY . . . . . ASSISTANT EDITOR

PUBLISHING OFFICE . . . . . 13-21 Park Row, New York
WESTERN OFFICE: 40 Dearborn Street, Chicago, Ill. LUCIEN W. MARSHALL, Manager
EUROPEAN OFFICE: 42 Old Broad Street, London, E. C. . . HENRY W. HALL, Manager

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CONTENTS.

EDITORIAL:
The Electromotive Force of the Clark Cell 557
The Competition of Water Powers 558
The Fixation of Nitrogen 559
Express Train in the New York Subway 559
The Spectra of Gases at High Temperatures 560
The Copper Mines of Vermont 562
The Use of Modern Telephone as Applied to Railroads 562
Inclined Cable Road Up the Hohensyburg, Westfalen Province, Germany, by Franz H. Koester 563
Cultivation of Rubber in Nicaragua 565
An Austrian Single-Phase Railway 565
Batteries and Accumulators with Heavy Acid 566
Trial of a 240-Horse-Power Diesel Engine 566
Convention of Illinois State Electrical Association 566
Electric Railways in Scotland 566
Negative Boosters, by J. Stanley Richmond 567
Convention of the New England Waterworks Association 570
The Prime Mover Situation 570
Electrolysis of Water Mains 570
Electrically Operated Hoisting Engines, by Emile Guarini 571
Insulating Materials in High-Tension Cables 572
N-Rays at the British Association 578
Electricity from Water Powers, by A. A. C. Swinton 579
Engineering and Trade Opportunities 582
Planning a Telephone System, by Samuel G. McMeen 582
The New Equipment of the New York Central's West Albany Shops 584
English Railway Statistics 584
A New Single-Phase Railway Motor 585
High-Tension Direct Currents 586
Electric Railroad in Peru 586
Electrical Patents 587
REVIEWS OF CURRENT ENGINEERING AND SCIENTIFIC LITERATURE 588
Quick Time in the Subway 590
Street Railway Week at St. Louis 590
An Arc Lamp with a Hot Wire Control 590
American Electrotherapeutic Association 591
Group Photograph of the Officers and Directors of the National Electrical Contractors' Association 591
The Distribution of Extra International Electrical Congress Papers 591
INDUSTRIAL SECTION:
The Hamilton-Holzwarth Steam Turbine 592
Motor-Generators 593
Fire Protection of the Marshall Field Department Store 594
Steel Towers for Canadian Transmission Line 594
A New Automatic Switch 595
New Forms of Oil Switches 595
The Power Plant of the Louisiana Purchase Exposition for Sale 596
The "Ideal" Motor-Driven Engine Lathe 596
CURRENT ELECTRICAL NEWS 597

RECENT ELECTRIC RAILWAY DEVELOPMENTS.

The electric railway men of this country assemble in annual convention in St. Louis next week. Probably, at no time has this gathering of experts, both technical and commercial, had more important matters to consider. The investment in trolley lines by many of the established steam roads of the country and, further, the adoption of electrical power for great terminal operations, lead to the question of serious competition, as well as that of a closer union between the great trunk lines and their growing younger brothers, the trolley lines. The very complete use to be made of electric power by both the New York Central and Pennsylvania lines at their terminal points in New York city, and the recent purchase of several trolley lines up the state, by the former company, are straws that show quite clearly the way the wind blows.

THE ELECTROMOTIVE FORCE OF THE CLARK CELL.

As has already been noted, the chamber of delegates at the recent International Electrical Congress decided not to take any definite step toward recommending the adoption of the Weston cell as the standard of electromotive force in place of the Clark, or toward recognizing the fact that the value of 1.434 volts now officially designated as the electromotive force of the Clark cell is undoubtedly incorrect. The feeling which led to this action was that of conservatism. It was thought that this was not the time to make any change. The Weston cell must prove its value after longer trials, and the official designation of the electromotive force of the Clark cell is sufficiently correct for commercial needs.

Taken in connection with this action of the chamber of delegates, the statement of the work done during the current year at the British Board of Trade Electrical Standards Laboratory is interesting. A report covering this is given in the *Electrician* (London) for September 23. Measurements were made on Clark cells prepared by Wolff, and great pains were taken in arranging the apparatus and avoiding all sources of error. The cells themselves were kept in a constant-temperature room, where the variation in temperature was not more than one-twentieth of one degree centigrade, for forty-eight hours before the comparison. In each case the electromotive force of the cell was found to be 1.4328 at fifteen degrees centigrade, and this result agreed exactly with the value for the cell which had previously been determined by the Physikalische Technische Reichsanstalt a year before. This result is a satisfactory proof of the care with which the work was done, and shows as well that the British electrical units are in good agreement with those of the Reichsanstalt. This value is also an agreement with recent work in this country. Professor H. S. Carhart has for some time contended that the value of the Clark cell should be 1.433. It is said, however, that no action looking toward the correction of the definition of a volt will be taken, because the difference between the old value and that which seems to be the correct one is less than one-half of one per cent, and hence is not of commercial importance.

One point of interest in regard to this work is that its accuracy was limited by the thermometers available. The limits of accuracy obtainable for measuring resistance are one part in 10,000; for measuring current and potential, one part in 1,000. But the thermometers available are graduated only in tenths of a degree, and are estimated to perhaps one-fiftieth of a degree. There would be no difficulty in providing an electrical thermometer which would enable temperatures to be read to one-five-hundredths of a degree, were there any means for calibrating them.

COMPETITION OF WATER POWERS.

Electrical supply from water power is an industry in which competition tends strongly to extremes, if it exists at all. The severity of competition between electric water-power systems that distribute energy in the same territory arises in large part from the peculiar nature of the business. At the start, each plant for the development, transmission, and distribution of electrical energy from water power usually represents a rather large investment per unit of its capacity for power delivery. Once in perfect operating condition, the expense for labor and materials is comparatively light, even when continuously carrying full load. In these respects, the system operated by water differs materially from one driven with steam, for, in the latter, the permanent investment per unit of power is usually less, and the cost of labor and supplies goes up much more nearly in proportion to the load. Every additional load connected to the lines of the steam-driven station increases, at least, the amount of fuel that must be consumed, and probably, also the cost of labor for handling it. Load added to an electric water-power system on the other hand calls for more flow through the wheels, but increases the cost of operation very little.

Meantime, heavy taxes, insurance, and depreciation charges, as well as interest and dividend requirements, are running against the electric water-power system, whether it carries any load at all or not, because of the large investment per unit of capacity. By the refusal to take on loads, the expense of the system operating with steam power can be greatly limited, but the expenses of the system that uses water power exclusively are much the same, whether particular loads are taken on or not. A short way of expressing this conclusion is to say that with steam power the greater part of the total annual charges against the electric system are variable with the load, while with water power, these total charges are more nearly fixed. This peculiar characteristic of electric water-power systems, due to the fact, that, the flow of the water itself costs little or nothing, while the plant for the utilization of the water requires a very large investment, leads to unprofitable rates when these systems are in competition. Such rates are fixed not with the intention to make a profit, but rather with the desire to avoid a part of the inevitable loss through fixed charges. Without some check on their competition, it seems impossible in many cases for electric systems that distribute the energy of falling water to make enough to cover fixed charges as well as operating expenses. If each of these water-power transmissions were owned and managed by a single person, the principle of self-interest might prove to be a sufficient regulator of competition. But corporate organization seems to be necessary for the development of these great enterprises, and experience does not show that corporate management will stop when the limits of reasonable competition have been reached.

Other factors that tend to carry competition among electric water-power systems to a ruinous point, are the comparatively small number of waterfalls that can be drawn upon for service in the same territory, and the trifling value of the entire plant for any other purpose than that for which it was designed. The small number of water powers encourages the hope that all of those supplying the same district may be brought under one control, and the competition thus ended. The fact that the hydro-electric supply system can be devoted to nothing else strengthens the determination to make it yield whatever it will in that line.

From ruinous competition, present or prospective, the electric systems that draw their energy from water power have naturally sought safety in combination. The unity of interests thus brought about extends not only to transmission and distribution systems in the same territory, but also, in many cases, to developed and undeveloped water powers on the same or adjacent rivers. One successful transmission of water power encourages another, and the development and transmission of energy from one fall, leaving others nearby, would often invite what might prove to be ruinous competition. Few, if any, important centres of population can be found in the United States to-day, where energy transmitted from water power is being distributed by independent private corporations. On the other hand, numerous instances can be pointed out where formerly separate systems engaged in the transmission of water power have come under a single management. Such a case is that of the transmission system centering in Los Angeles, California, with more than a half dozen generating stations, on at least four streams. Another example in the same state is found in the system that encircles the shores of San Francisco bay, which connects with five water-power plants in the distant mountains and supplies energy in fully two score of cities and towns. In Montreal, water power from three generating stations, on as many rivers, now distributed by a single corporation, though two of these stations were formerly in competition for the business at that city. Four water powers on two rivers are now owned in common and all develop energy for Manchester, N. H., some miles distant from each of them. Besides the generating stations at Mechanicsville and Spier Falls on the Hudson, the interests that transmit electrical energy to Albany, Schenectady and Troy own two undeveloped falls on the same river, and a third on a tributary stream. These fine water powers seem to be the only important ones within easy distance for transmission that can be devoted to electrical supply in the cities named. At Niagara Falls, much competition of electric plants seems to be in sight, but some persons think it will vanish when those now under construction are completed.

There is a pronounced increase in activity in business conditions of the electrical field. Many of the manufacturing branches of this constantly expanding industry are booking excellent orders for fall and winter deliveries. The doubtful feeling that prevailed during the greater part of the present year, up to now, is rapidly disappearing, and a spirit of confidence in the future growth of the demand for electrical machinery and appliances has taken its place.

FIXATION OF NITROGEN.

Two important papers again direct attention to the problem of devising means of bringing the nitrogen from the atmosphere to a condition where it can be used as a plant food. In an address before the agricultural subsection of the British Association for the Advancement of Science, the chairman, Dr. William Somerville, referred to the chemical fixation of atmospheric nitrogen and to the experiments which are now being carried out with nitragin, a preparation containing organisms which are capable of taking up nitrogen from the air and combining it with other substances so that it may be useful for plants. The second paper referred to above was presented to section C, of the International Electrical Congress, at St. Louis, by Mr. J. S. Edstrom, and it takes up a third method of fixing nitrogen; namely, the electrical method.

The chemical method, which is considered by Dr. Somerville, is, in a sense, partly electrical, since it depends upon the action of calcium carbide upon nitrogen. This gas, freed of oxygen, is passed through finely disintegrated calcium carbide at a high temperature. One atom of carbon is displaced by two atoms of nitrogen, and calcium cyanamide is formed. When pure, this substance holds about thirty-five per cent of nitrogen, but in crude commercial form contains only about twenty per cent. Experiments conducted during the past three years at Posen and Darmstadt, Germany, have shown that calcium cyanamide itself is a useful nitrogenous manure. Field experiments have given results about twenty per cent below those obtained by the use of an equal amount of sulphate of ammonia. In prepared soil in pots, the results surpass those obtained both with nitrate of soda and sulphate of ammonia. It is thought that the less satisfactory yields obtained in the field were due to the action of the organic acids on the cyanamide, for when this substance is treated with acid, a dicyanamide is formed, which is directly poisonous to plants.

A few years ago, a good deal of interest was excited by the announcement that those organisms of the nodules of the roots of Leguminosæ could be purchased in a form convenient for artificial inoculation. These organisms or bacteria, as mentioned above, have the property of extracting nitrogen from the air and fixing it in combination with other elements, so that it becomes available as a plant food. Extensive experiments are being carried out during the present year, both in this country and abroad, and doubtless we shall, before long, know a good deal more about the progress of this line of work than we do now.

The electrical method, described by Mr. Edstrom, does not differ in principle from those which have already been described in the ELECTRICAL REVIEW. Priestley and Cavendish, a hundred years ago, discovered that electric sparks, when passed through the air, caused the nitrogen and oxygen of the air to combine, with the formation of nitric acid. A number of investigators have worked, and still are working, to develop a process of applying this action commercially. One of the best-known systems is that devised by Bradley and Lovejoy, who have done an enormous amount of work in an excellently equipped establishment at Niagara Falls. The method described in this paper is due to C. Birkeland and S. Eyde, of Christiana. The two electrodes between which the arc is established are connected to a high-voltage generator. The points of the electrodes are at such a distance that the pressure of the generator can maintain an arc between them. Placing the electrodes in a strong magnetic field causes the arc to be blown away from the field. When the arc first jumps across the gap, the difference of potential between the electrode falls; but as the arc is blown outward by the magnetic field, the voltage rises until it again reaches a point sufficient to cause another arc to start. As soon as this is done, the lower resistance of the new arc extinguishes the older and longer one. It is said, that this action is so rapid, that several thousand arcs are formed per second, and that the appearance to the eye is that of a disc of light. If the source of supply is direct current, the arcs are formed all on one side. If an alternating supply be employed, the arcs are formed on two sides of the electrodes.

It is said, that, in this system, there is no objection to employing a large amount of energy in the arcs. The efficiency claimed for the process, in the latest form, is 900 kilogrammes of nitric acid per kilowatt-year. In this estimate, the energy referred to is that in the disc of arcs itself. This is considerably better than the published results of other systems, though we have seen no recent statement of the advance which other inventors have made. It is evident, that, unless there are some difficulties which have not been made known, we shall soon be in possession of a commercial process of extracting nitrogen from the air for use in fertilizers. It is estimated, that, at the present rate of consumption, our known natural supplies of nitrate will last till 1940 only, but the indications are that long before that artificial nitrate will replace the natural article, and that the future will be able to take care of itself.

EXPRESS TRAIN IN THE NEW YORK SUBWAY.

The express train which made a trip in the New York subway Monday afternoon, October 3, carrying representatives of the New York press, demonstrated the great improvement in rapid transit which is about to be put into service. The trains, run in regular service, may not make quite as good time as was made on this trip, but the speed attained gives a good idea of what may be expected. The run from the City Hall to the heart of Harlem was made in the record time of fifteen minutes, and the speed at times must have been over fifty miles an hour. There was no hitch whatever during the run, and everywhere the great care taken to ensure the safety and comfort of the passengers was apparent. The city has been waiting impatiently for the completion of this important road, and it can not be put into service too soon for those who expect to use it. We are confident that, after the formal opening, nothing but praise will be heard from the public in regard to what will certainly be the most important and best urban railway in the world.

SPECTRA OF GASES AT HIGH TEMPERATURES.[1]

BY PROFESSOR JOHN TROWBRIDGE.

The new theories in regard to the complexity of the atom, together with a multiplicity of ionization phenomena, make the results of spectrum analysis obtained by the discharges of electricity in glass or quartz tubes difficult of interpretation. To use ordinary language "so many things can happen," such as dissociation; combination with the gases set free from the walls of the containing tubes; masking of the spectrum of one gas by that of another, reversals of spectrum lines and so on.

These complicated conditions which accompany our study of gaseous spectra make it almost impossible to conclude from laboratory experiments that we have imitated the phenomena presented by the distant stars.

For several years I have been endeavoring to obtain new series of hydrogen lines which might presumably manifest themselves at very high temperatures. In the progress of this work I have obtained a number of interesting facts which I shall dwell upon in a brief manner in this paper; but I have failed to find a new series of hydrogen lines, possibly from the reason that the reactions both in glass and quartz vessels mask the series. It seems impossible to experiment at a higher temperature than I have obtained, certainly if one employs such vessels as I have mentioned.

My investigations have been conducted with a storage battery of 20,000 cells, which were used to charge large condensers. The advantages in using a storage battery for experiments in spectrum analysis are well recognized. These advantages are especially seen in the employment of condenser discharges. When the condensers are charged through a large liquid resistance they charge to the same potential each time, and then discharge without the intervention of a discharger, through the Geissler tube. The number of discharges can be closely regulated by the amount of liquid resistance which connects the poles of the condensers to the battery. The regularity of such discharge through the Geissler tubes is remarkable. In popular language one can call the arrangement an electric clock, for the discharges follow each other at regular intervals. In this way one avoids the spark at a discharger and is sure of always obtaining the same difference of potential at the ends of the Geissler tube. The highest temperature to which one can submit a gas is presumably that of the electric discharge from a condenser; opinions differ in regard to the degree of heat which one can obtain by such a discharge. The limit I have reached is the volatilization of silica; perhaps 1,800 degrees. At this temperature the spectrum shown by all gases in narrow capillary tubes consists of a continuous spectrum crossed by broad bands due to silica or to an oxide of silica; the gaseous spectra are completely masked. This masking seems to be due to the greater conductibility of the volatilization products from the walls of the tubes and from the metallic terminals. It seems to me that this variation in conductibility is sufficient to account for the phenomena of masking without recourse to a theory of electrons which provides for suitable damping of electrical oscillations. The electron theory may be an ultimate explanation, however, of electrical conduction.

When terminals of different metals are employed in capillary tubes of glass or quartz, and are separated four or five millimetres, complicated phenomena result from powerful condenser discharges through the rarefied gases contained in these tubes.

All specimens of glass which I have tried, soft German glass, lead glass, Borsilicon glass, or Jena glass, give broad bands due to silica; lead glass gives, in addition, lead lines. Jena glass gives a very strong line of boron at wave length, 3,451.49. These lines and bands are obscured by a continuous spectrum.

The narrow capillaries with metallic terminals, which I have used, may be called electric furnaces in which there is no permanent product or permanent decomposition; moreover the spectra which we observe do not reveal all that the capillaries contain. Hydrogen may be present, but it is concealed. Oxygen shows its presence only by probable oxides; the constituents of rarefied air are undoubtedly always there. The conditions which prevail in the case of discharges in such narrow capillaries seem to be analogous to those in the case of discharges under liquids. In this latter case we also have reversals of metallic lines; and moreover certain characteristic lines of metals are wanting—see "Spectra from the Wehnelt Interrupter," Harry W. Morse. Proceedings American Academy of Sciences, May, 1904.

These results make one doubtful in regard to the entire subject of spark spectra which are observed between metallic terminals in ordinary air; and we are forced to ask, what influence does the environment have upon the character of these spectra—to what must we attribute the presence of oxygen? And even if we take spark spectra between metallic terminals in an atmosphere of hydrogen or nitrogen we are not sure that the results are not modified by the gases which are occluded in the metallic terminals.

Are we sure that, even in electrodeless tubes, helium is a product of disintegration of radium; a transmutation, so to speak; and is not a result of the electrical stimulus in the environment of glass or quartz a stimulus which may bring to light the helium which has refused to manifest itself by chemical analysis?

In general it may be said that the greater the conductibility of the volatilization products, from either the walls of the tubes or from the metallic terminals, determines the occurrence of the spectral lines or bands. The spectrum, for instance, of silica completely masks the spectrum of the iron terminals when the latter are placed not more than five millimetres apart. When the terminals are of different metals the spectrum of the more volatilizable metal predominates; or more strictly, the spectrum of the better conducting vapor.

Another striking fact brought to light by such discharges in capillaries is the reversal of many of the spectral lines on broad bands. The broadening of the lines of the metals is generally toward the red end of the spectrum. The quantity of the discharge appears to be the important factor in determining the character of the spectra; electromotive force, *per se*, does not give new lines which can be detected by photography. The effect of high electromotive force begins to be evident at high exhaustions and then only in producing cathode and X-rays.

This latter fact can be well shown by a Tesla coil actuated by a Cooper Hewitt mercury interrupter such as was employed by Dr. G. W. Pierce (proceedings American Academy, 1904). With a suitable step-up transformer, in connection with such an interrupter, I have studied the spectrum of hydrogen, and have not obtained a spectrum which differed from the one obtained by the same amount of energy with a lower voltage. The high voltage ranged from 100,000 volts to 3,000,000.

The broadening of metallic lines seems to indicate an oxidization. One can con-

[1] Presented before section A—general theory—at the International Electrical Congress, St. Louis, 1904.

ceive of a loading of the metallic molecule by various degrees of oxidization which leads to a broadening toward the red end of the spectrum, or in other words to longer wave lengths, and an unloading due to dissociation which leaves the molecule free to emit shorter wave lengths. That an oxidization results from a discharge of electricity in glass or quartz tubes filled even with apparently dry hydrogen seems to me to be evident from my experiments. The unavoidable presence of water vapor in glass, and I may add, in quartz tubes, lends color to this oxidization theory; this vapor is dissociated by the electric current, the oxygen,

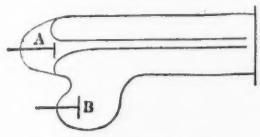


FIG. 1.—GEISSLER TUBE.

set free, combines with the molecules of the metals, or with the molecules of silica and its metallic impurities.

The following experiment illustrates this oxidization:

A Geissler tube, Fig. 1, with an internal diameter of one inch, was provided with an inner capillary, one end of which was blown to the walls of the larger tube; the other end free inside this larger tube. An electric discharge passed between two ring electrodes A and B, which were placed in the larger tube. The discharge, therefore, started, so to speak, in the larger tube, passed through the narrow channel of the capillary and emerged to the cathode. The tube was filled with pure hydrogen which was dried by phosphoric pentoxide. Under the effect of powerful condenser discharges, the four-line spectrum was much enfeebled in the capillary; the red color, characteristic of condenser discharges in hydrogen, gave place to a brilliant white light, and when the capillary was viewed end on, a continuous spectrum was seen. When, however, the discharge issued from the capillary a brilliant red aureole was seen around the end of the capillary. This aureole gave a much enhanced four-line spectrum. The temperature inside the capillary was sufficient to volatilize the walls of the capillary, and, therefore, was competent to decompose the water vapor into oxygen and hydrogen. Just outside the end of the capillary, the temperature fell to the point of recombination of these gases to water vapor.

In another experiment the Geissler tube G, Fig. 2, was placed between two manometer gauges, and was exhausted to such a degree that the electric discharge failed to pass. One end of the Geissler tube, that nearest to the pump, was shut off by means of a stop cock B; and dry oxygen was admitted to the pump until the manometer gauge connected with the pump indicated two centimetres pressure. The stop cock was then opened so as to admit the gas to the Geissler tube. The corresponding manometer gauge at the opposite end of the Geissler failed to register the requisite equalization of pressure, there having arisen an oxidization of the mercury meniscus by means of which the capillary constant between it and the glass had been changed. This holding of the mercury meniscus was large and had to be overcome by vigorous tapping of the tube. An analogous effect was obtained when the Geissler tube was filled with rarefied air, and also when it was filled with nitrogen. When, however, it was filled with dry hydrogen, the holding effect was comparatively inappreciable. The oxygen produced by the dissociative effect of the electric discharge combined with the hydrogen and no longer oxidized the surface of the mercury. In this con-

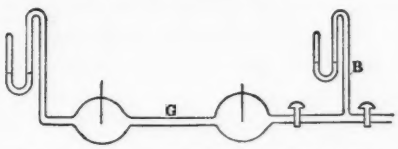


FIG. 2.—GEISSLER TUBE BETWEEN TWO MANOMETER GAUGES.

nection it may be observed that the mercury meniscus in the Lippman electrometer is affected principally when it is made the positive pole, and, therefore, oxygen is liberated.

Perhaps the most striking experiment in this connection can be made with the steady current from a large storage battery. When Geissler tubes, preferably a half a centimetre internal diameter are provided with copper terminals, and are filled with dry hydrogen at pressures of one millimetre to one-tenth of a millimetre, a steady diminution in the pressure of the gas results from the application of the discharge; the light of the spectrum grows dimmer and dimmer, then the cathode rays appear, finally the X-rays, and then no discharge can be forced through the tube until a much higher electromotive force is employed, or heat is applied to the tube. This heat evidently drives off water vapor from the walls of the tube together with air, a fresh application of the steady current again diminishes the pressure in the tube to an apparent vacuum. Thus one can exhaust, so to speak, a Geissler tube by employing a steady current of electricity to dissociate the ever-present water vapor. With copper electrodes, the oxidization produced by this dissociation is more evident than with other metals; although I have observed it with magnesium terminals, with iron terminals and with other metals.

These experiments lead me to believe that, just as in chemical reactions, a certain amount of water vapor or humidity is essential to conduction in gases, whether brought about by what is called chemical affinity or electrolytic action.

I have dwelt upon the broadening of the lines of metals in capillary tubes. This phenomenon is also observed with hydrogen lines, and was first noticed by Liveing and Dewar, *Chemical News*, 47, p. 122, 1883. These authors attributed the broadening to compression of the gas in the narrow capillary under the effect of a powerful condenser discharge. Their method of experiment was as follows: the tube was exhausted only to perhaps five or six centimetres pressure, so that a white discharge of a spark nature passed through the capillary and then spread out to electrodes placed in the large ends of the tube. When the tube was viewed end-on, a continuous spectrum was seen in the capillary; moreover, this continuous spectrum was crossed by a dark line which resulted from the absorption of heat in the colder layers of gas in the larger portions of the tube.

The broadening of the spectra of the vapors of metals which I have observed in capillary tubes has thus its analogy in the case of gaseous spectra.

Having obtained reversals of the spec-

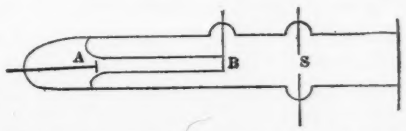


FIG. 3.—GEISSLER TUBE, SECOND GAP AT S.

tra of metallic vapors under new conditions, I was naturally interested in the experiment of Liveing and Dewar, especially since a controversy had arisen between M. Cantor and E. Pringsheim in regard to the possibility of the reversal of gaseous lines in Geissler tubes. M. Cantor[1] concluded from his experiments that such reversals do not occur in the phenomena of luminescence, such as one obtains by the discharges of electricity in Geissler tubes. Pringsheim objected to these conclusions on the ground that Cantor did not observe a sufficiently nar-

[1] *Ann. der Phys.* n. 3, 1900, p. 462.

row portion of the spectrum of the gas and did not use sufficient dispersion. Pringsheim[1] quotes the results of Liveing and Dewar in support of his position.

In repeating Liveing and Dewar's experiment, it occurred to me that objection might be brought against it on the ground that it was a spark discharge and not a clearly marked glow or luminescent discharge such as Cantor evidently had in mind. I therefore placed a second spark gap (Fig. 3, S) just outside the inner capillary of the large Geissler tube provided with an inner capillary, as I have previously described in speaking of the temperature inside a capillary and in the space just outside. The discharge passed first through the capillary and then by means of an outside connection through the second spark gap; thus the light from the capillary passed through the light from the second spark gap. In both cases the light was a glow or luminescence and not a white spark discharge, the pressure in the tube being from one to two centimetres.

A Rowland grating was employed and an eye-piece was fixed on the C line of hydrogen. The second spark gap gave a fine bright line of the apparent length of the slit, the capillary a continuous spectrum, and where the fine bright line crossed this continuous spectrum it was reversed.

Kirchhoff's law of radiation thus applies to the radiation in Geissler tubes, and Pringsheim's contention is justified. If the solar corona is an electrical phenomenon of the nature of luminescence it can exhibit either bright lines or dark lines according as it is hotter or colder than the background.

In this study of the upper limit of temperature which one can reach by electric discharges through rarefied gases, we perceive that spectrum analysis is one of the most difficult analyses which modern science has revealed. There are a few broad facts such as Doppler's principle and the reversal of spectral lines according to Kirchhoff's law; on the other hand there is ionization, dissociation, adsorption and absorption, all modified by the glass or quartz vessels which must be employed.

M. Cantor calls attention to the fact that Hittorf failed also to observe reversals of spectral lines in the case of electric discharges in Geissler tubes. Hittorf speaks of a first series of hydrogen lines which are seen with feeble discharges. This feeble spectrum with its bands seems to be a peculiarly luminescent effect in which any translatory or colliding effect of the molecules is a minimum. The new theories in regard to the composite nature of the atom seem to demand an extension of our views in regard to the nature of the light emitted by atoms and their aggregates under the stimulus of an electric discharge. The phosphorescent and fluorescent light of a gas under this stimulus may arise from the mechanism of the atom and therefore may not give sensible heat. The combination of atoms into molecules, and their dissociation and formation of new combinations, may give the spectra we usually observe under the effect of fairly strong electric discharges, and provide the sensible heat which can be measured by the bolometer or the thermal junction.

Spectrum analysis of the future thus becomes more and more difficult of application, and one of its most important fields is in the study of phosphorescent and fluorescent light emitted by gases. We seem to be on the point of regarding the light and heat of the sun more from the electrical standpoint. And the study of discharge of electricity in rarefied gases assumes a great importance.

[1] *Ann. der Phys.*, n. 5, 1900.

The Copper Mines of Vermont.

Mr. Walter Harvey Weed, of the United States Geological Survey, made a brief reconnaissance in September, 1903, of the copper mines of Vermont. The salient features of the deposits studied by him in this preliminary visit are described in a paper which is included in the Survey's recent bulletin (No. 225) entitled "Contributions to Economic Geology, 1903."

Copper mining was once one of the chief industries of the state of Vermont. Prior to the opening of the Michigan deposits, Vermont's most important mine, the Ely, was the largest copper producer in the country. The deposits belong to a type that is well known in many parts of the world and that includes some of the most famous producers. In character and copper content the Vermont ores correspond to the ores found at Ducktown, Tenn., and can probably be as cheaply mined and treated as those of that locality. They are also similar to the deposits found in the province of Quebec, Canada, which lie almost due north of the Vermont belt.

The Vermont deposits contain vast amounts of low-grade copper ore, which only await development through some cheap method of treatment to become phenomenal producers. The ores present considerable variation in their content of silica, but are of fairly constant mineralogic character and are very uniform in their percentage of copper.

These deposits occur in the hilly region that forms the eastern part of the Green mountains. The belt contains three districts, Corinth, Copperfield, and South Strafford, which lie in a north-south line from seven to ten miles west of Connecticut river.

The thickness of the ore bodies varies at different localities. At the Elizabeth mine the ore was as much as 100 feet wide in the open-cut workings, and on the 225-foot level it is thirty-five feet between walls. The ore has a maximum width of twelve feet at the Union and at adjacent properties in Corinth township, and of twenty feet at the Copperfield property. The depth to which these deposits extend is not known. At the Ely mine, the inclined shaft is 3,400 feet long, and its bottom is below the sea level. The ore body consists of several lenses, so that one lens may pinch out; but in the Union and Ely mines the ore continues in overlapping lenses to the greatest depth attained. The ore bodies are remarkably free from water. At a depth of 3,400 feet on the dip, or 1,500 feet vertically, the Ely ore body is very dry, the water of the mine being confined to a few hundred feet of upper workings. The ore and incasing rock are very solid in all the mines and practically no timbering is used.

Mr. Weed gives interesting details about the history, equipment and present development of mines in the three districts of the belt. The Elizabeth mine, near the town of South Strafford, was opened as early as 1793, and its magnetic pyrite was used for the manufacture of copperas. The great Ely mine was discovered in 1821, and has been successfully worked most of the time since then. Bad management and litigation have several times caused the mine to be closed down or to change hands, but whenever mining operations have been continued it has yielded a large output of copper.

The Use of Modern Telephones as Applied to Railroads.

In a paper read at the annual meeting of the Association of Railway Telegraph Superintendents at Indianapolis, Ind., Mr. B. A. Keiser gave some interesting statistics on the development of the telephone in connection with railroading. From a beginning in which the telephone was merely used for public information, it has developed to an indispensable feature of railroad handling. As an example he cited the New York, New Haven & Hartford Railroad Company, which, from a modest start, has increased its telephone system in the past ten years so that it now has 1,500 telephones besides a number of private branch exchanges and its own metallic circuits between various cities. Telephones are used in operating departments, towers and switch cabins and save a great deal of time which was formerly lost in despatching information by messengers.

Inclined Cable Road up to the Hohensyburg, Westfalen Province, Germany.

By Franz Koester.

THE incline cable railway leading up to the Hohensyburg was opened in September, 1903; the road forming the latter part of an extension to the Horder Kreisbahnen system.

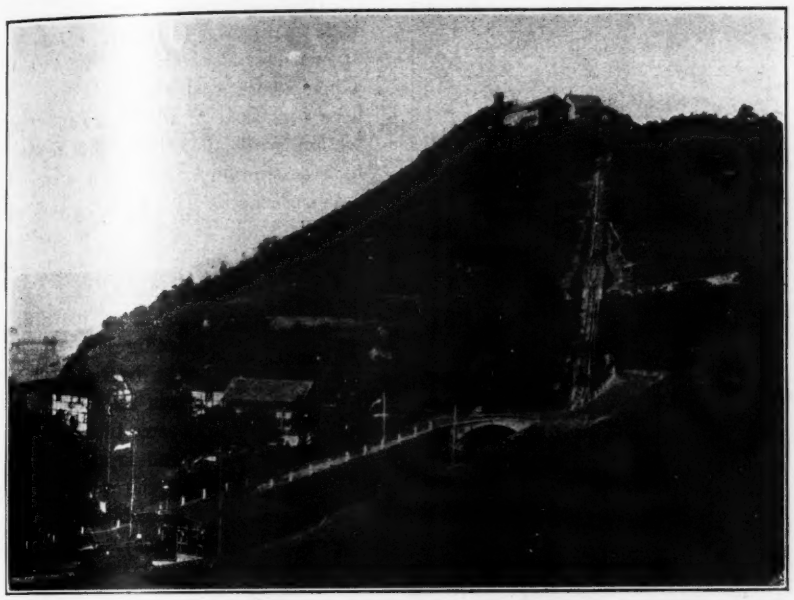


FIG. 1.—GENERAL VIEW OF THE INCLINED CABLE ROAD, SHOWING ONE OF THE STONE ARCHES.

The cable road connects with the adhesion road leading from Westhofen to Hohensyburg which was opened at the same time. Both the cable and adhesion roads are owned by the General Local and Street Railway Company, of Berlin; the former road was built by the Allgemeine Elektricitäts-Gesellschaft, of Berlin.

The inclined railway was built for the purpose of carrying excursion parties, and the schedule is arranged with this object in view. The entire length of the line is 445 metres (1,459.6 feet), and the gauge is 1 metre (3.28 feet); the same as on the adhesion road.

The difference in elevation between the terminals of the road is 93 metres (305 feet); the elevation being overcome by means of a number of inclines on which the grade varies from a minimum of 15.5 per cent to a maximum of 31.6 per cent; the former being at the beginning of the ascent and the latter at the top, thus reducing the power required for starting to the lowest possible value. The road ends on a plateau at the top of the mountain.

The road-bed is 2.12 metres wide (7.9 feet) at the crown, and 3 metres (9.8 feet) wide at the base, the slope of the sides being five to one where the bed is cut in the solid rock in the mountain side and 1.25 to 1 where it is laid on good soil or is built on hills not exceeding 5 metres (16.4 feet) high.

There are two stone arches on the line, one carrying a roadway under and the other over the tracks. The rails are a modification of the standard T-rail, in order to admit of the proper operation of the brake shoes which act on the sides.

The fish-plates are of angle-iron construction, the details of the rails and joint being well shown in the figure. The ties are of iron-trough construction and are spaced 1 metre (3.28 feet) apart, ballasted with 25 centimetres (0.08 foot) of trap rock. All the rail joints on the line are supported; the ties at each joint being securely anchored in a bed of concrete, 2 metres (6.5 feet) long and 7 metres (2.3 feet) wide.

The rail, which is 10 metres (32.8 feet) long, is clamped to the tie by a fastening which fits into a recess in the fish-plate, and makes an exceedingly rigid joint. Unusual precautions are necessary on this road to prevent creeping of the rails and movements due to the operation of the brake shoes which work against them.

As the road is built with a single track, a turn-out sixty feet long is provided at the centre of its length, the distance from centre to centre of the tracks at the turn-out being 2.6 metres (8.5 feet). The cars are 2.1 metres (6.8 feet) wide. The operation of the switch at the turn-out is automatic, the outer rails being continuous and the inner ones being cut away to allow for the passage of the brake shoes and the cable. The outer wheels of the cars are provided with a double set of flanges, while the inner wheels are coned and have a single flange. The cable is carried on cast-iron rolls, varying in size from 310 to 520 milli-

FIG. 2.—TWO CARS PASSING ON THE TURN-OUT.

metres (1 to 1.7 feet) in diameter and spaced from 7 to 8 metres (23 to 26 feet) apart. On the straight track two rolls on one axle are employed, while on curves, and at the turn-out, the rolls are carried on separate axles inclined at an angle to the horizontal.

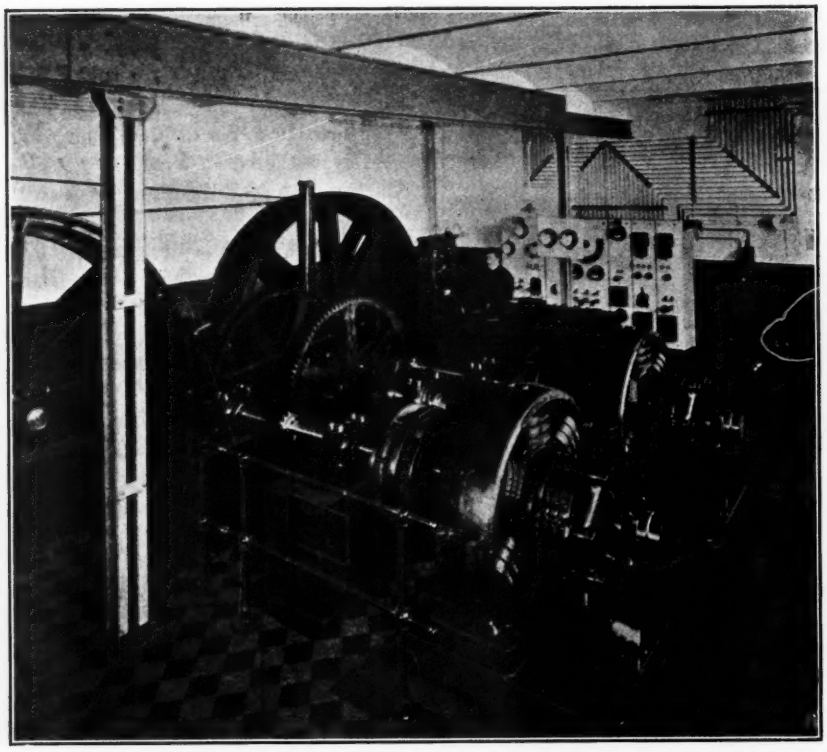


FIG. 3.—ENGINE ROOM, SHOWING MOTORS AND INTERMEDIATE GEARING.

There are two stations, one at the upper and one at the lower end of the line. The lower station is built of brick and wood, the track and platform being roofed over. The upper station is also of brick and wood construction and is built in steps on the incline. Besides containing the track and platform which are roofed over, it also contains the power plant for operating the road and the cable-wheel and pit. In the upper part of the building is the storage-battery room and two rooms for the employés. A car-inspection pit is provided under the shed at each station.

Both stations are lighted inside and out by sixteen-candle-power incandescent lamps. The machine room is equipped with the motors, intermediate gearing and cable-sheaves, around which the cable is wound several times in order to prevent slipping.

The electrical equipment was furnished by the Allgemeine Elektricitäts-Gesellschaft, of Berlin, and the mechanical, by "Rette," Sentsche Elbschiffahrts-Gesellschaft, Dresden. The sheaves are 3 metres (9.8 feet) in diameter and are provided with a heavily built gear which is bolted to the wheel. In order to prevent excessive wear on the cables the grooves in the sheaves are lined with wood.

The motor is coupled to the intermediate gearing by means of a Zodel-boith coupling which allows for reversing. The intermediate gearing is provided with a brake which may be operated either automatically or by hand, in the engine room, and is used in case of emergency for stopping the cars on the line.

In case the engineer should neglect to shut off the power and stop the cars when they have arrived at the stations an emergency lever is placed in the inspection pit at the upper station. This comes in contact with the car and releases a weight in the engine room which in turn serves to operate the automatic brake. Spring buffers are also provided at both ends of the line. A reduced profile of the road properly connected by gearing is provided in the engine room so that the engineer may at all times be able to accurately locate the cars on the line.

The cable is of cast steel and of a patent construction with an outside diameter of 25 millimetres (1 inch). It is made up of five strands, which are wound around a hemp core, each strand is made up of nine wires, one of which has an elliptical section, while the other eight are circular in cross-section and have a diameter of 2.45 millimetres (0.1 inch). The weight of this cable is 2.8 kilogrammes (6.2 pounds) per metre. It is designed with a factor of safety equal of 11.5.

The greatest tension on the cable occurs when the ascending car filled with passengers enters the heaviest grade and the greatest power is required from the motor when at the same time the descending car is empty and is at the place of least grade. Under the worst conditions the tension on the cable is 29.3 kilogrammes (64.6 pounds).

The sheaves are motor-driven by means of gearing, the engine room being equipped with two motors, one of which is held in reserve. The power required for operating the road amounts to 59.5 horse-power and adding fifteen per cent to this, in order to provide for friction and braking, the necessary power is raised to 68.5 horse-power.

The motors installed have a normal rating of seventy-two horse-power; revolve at a speed of 390 to 410 revolutions per minute and take current at 500 volts. They are capable of operating satisfactorily with an over-load of thirty per cent. The motors are of the direct-current, shunt-wound type, the levers of the

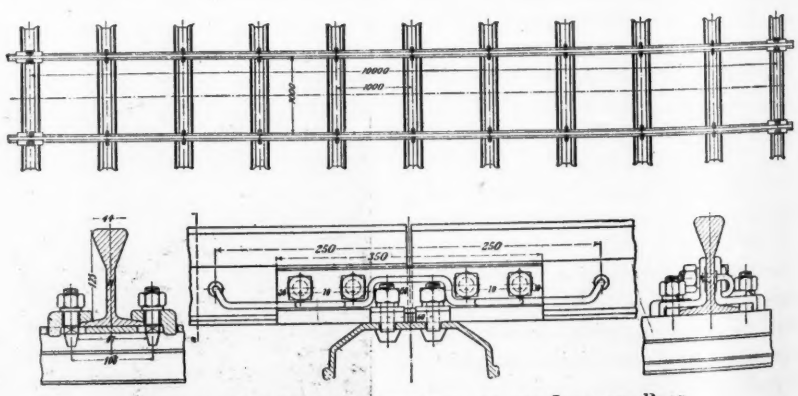


FIG. 4.—THE TRACK CONSTRUCTION OF THE INCLINED ROAD.

field and armature rheostats being so connected mechanically that the resistances of the armature circuit are not cut out before the field circuit has been closed. By this arrangement the attendant is able to send current into the armature only after the magnetic field has reached its normal intensity. An automatic circuit-breaker is connected in the circuit of each motor.

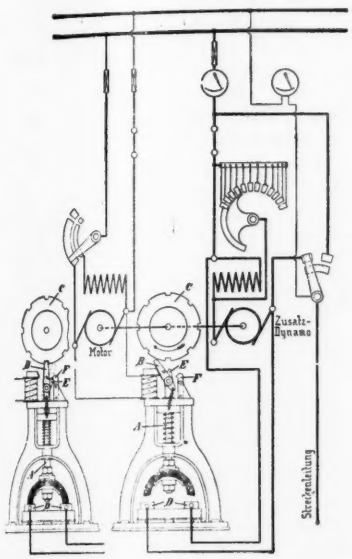


FIG. 5.—AUTOMATIC SHORT CIRCUITING DEVICE.

The direct current for the motor is furnished by a power station in Schwerte, wires having a cross-section of 95 square millimetres (0.7 inch) being carried on an iron pole line. This current also supplies power for the adhesion road at 500 volts pressure. To compensate for the drop, a booster-set, consisting of a generator furnishing 200 amperes at ninety volts, and running at a speed of 550 revolutions per minute direct-connected to a 28.5-horse-power 500-volt shunt-wound motor, is furnished. The return circuit is formed by the rails of both the cable and adhesion roads which are bonded with copper.

In order to ensure the continuous operation of the station, in case of any breakdown in the line, a storage battery of 240 cells and having a one-hour discharge-rate of 148 amperes has been provided. For charging the batteries, there is installed in the operating station a booster-set, consisting of a direct-current generator, capable of furnishing seventy-eight amperes at 150 volts or fifty-six amperes at 160 volts, the generator being direct-connected to a 500-volt direct-current motor. An automatic short-circuiting arrangement is provided, which operates in case the motor of the booster-set should, for any reason, reverse its direction of rotation; the arrangement for this circuit is shown clearly in the cut. A rotary transformer-set in the operating station transforms the 500-volt current to 220 volts and furnishes power for lighting the station and grounds in the vicinity.

The cars for the cable road are specially built, for the average grade of one in five, they have a maximum capacity of forty persons; are 7.3 metres (23.9 feet) long inside the buffers and 5.9 metres (19.3 feet) long inside the car; they are 2.1 metres (6.9 feet) wide and the axles are on 3.2-metre (10.5-foot) centres; the car bridge, built of angle-iron, rests on eight springs on the trucks.

The cars are entered at the side. The interior is divided into four compartments, the seats in the rear one being so arranged that they may be removed to increase the standing room. Each car is equipped with two elastic buffers.

As one car ascends while the other descends, the ends of the cable are fastened on the car body; this necessitates very careful work in order to avoid trouble due to disintegration from various causes at the fastenings. The ends of the cable terminate in conical-shaped boxes; the hempen core is removed for a length of 200 millimetres (6.5 inches) and the end of the cable, leaving a length free, is then wrapped tightly with wire. The strands are then separated inside the holder, the ends bent inward, and each strand carefully cleaned, a composition consisting of ten per cent copper, ten per cent antimony, and eighty per cent tin is then poured into the cable-holder, previously warmed, and allowed to solidify.

Each car is provided with three sets of rail clamps, two of which are automatically operated in case of accident to the cables. The third is operated by hand and may be controlled from either the front or rear platform. The automatic brake operates in case of a break in the cable or if the car should become stalled and the cable accumulate slack. In operation the brake clamps the rail, and at the same time the flangeless wheel, and forces it against the rail.

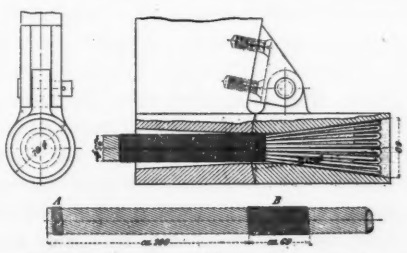


FIG. 6.—DETAIL OF CABLE FASTENING.

Every possible provision has been made to ensure the safety of operation; the cars and stations are equipped with audible bell signals and visible light signals, and are at all times connected by telephone. In addition to this, as previously described, the engineer has, at his side, a reduced-scale plan of the road, by which he is enabled at any instant to note the position and condition of the cars on the line. A series of very complete tests has been made on the road and its equipment since its opening. The results in every case have been entirely satisfactory.

Cultivation of Rubber in Nicaragua.

On the plantation of Mr. J. C. Horter, in the Pearl lagoon district, Nicaragua, the cultivated rubber trees were recently tapped for the first time. The trees are seven years old, having been planted in 1897 in a nursery, and transplanted the following year in a clearing. They have attained heights of from forty to forty-five feet, and measure in circumference from seventeen to thirty inches. Six thousand of the trees were cut and 534 pounds of rubber, an average of one and one-third ounces to a tree, obtained. Mr. Horter, in the absence of precedents, went about the work very conservatively, and is not disappointed with this slight yield. In fact, upon tapping a tree experimentally two weeks after the first attempt, it yielded as much rubber as at first. A third tapping gave similar results, without harm to the tree. The trees are healthy and all seem to have been benefited by the treatment. The results of next year will probably show definitely how much rubber can be got from a given number of well-cared-for eight-year-old trees, and will probably answer the question, for the existing conditions at least, as to whether the cultivation of rubber trees can be made a financial success.

An Austrian Single-Phase Railway.

The European journals report that the single-phase railway running through the Stubai Alps, in Austria, was opened on August 1. This road is fed by a single trolley at 2,700 volts from one transformer substation. The feeder voltage is 10,000 and the frequency is forty-two cycles per second. The road, which has a gauge of one metre, is eleven and one-half miles in length. The maximum grade is 4.6 per cent and the highest speed reached is fifteen and one-half miles per hour. The road ascends from an altitude of 1,870 feet to 3,500 feet and it is said that its cost was $555,000.

Batteries and Accumulators with Heavy Acid.

An attempt to construct an electric battery without using the usual inorganic acids has been made by M. Mario Buffa. In electrolyzing sodium oleate and sodium laurostearate, he found that a counter electromotive force of nearly two volts was set up. It occurred to him that it might be possible to construct a battery, using these substances as the electrolyte. He found that many of the fatty acids or their salts would act upon the metals, setting up a considerable electromotive force, but the electrolyte itself was a poor conductor, and hence valueless for use in a battery. However, he found that laurostearic acid is a good conductor, and he has constructed a number of primary batteries using this substance as the exciting material. Laurostearic acid is not soluble in water, but is soluble in alcohol and in ether. It melts at forty-four degrees centigrade, and the formula is given as $C_{12}H_{24}O_2$. It also dissolves in glycerine, forming an oil. It was found that a suitable electrolyte was formed by saponifying laurostearic acid by means of sodium hydrate. The proportions of the mixture are 4.5 parts of the acid, 12 parts of the sodium hydrate, and 83.5 parts of water. This solution has a low resistance, and gives a high number of ampere-hours per unit weight. It has one defect, namely, its tendency to crystallize. This may be prevented by coating the surface with a layer of paraffin. The best negative electrode for the batteries is amalgamated zinc. Carbon, iron, nickel or copper, wrapped in some depolarizing material, may be used as the positive electrode. Potassium permanganate can not be used, since it diffuses through the soap. Peroxide of copper, lead, manganese and nickel are satisfactory. This soap can also be used as the electrolyte for cells of the Edison type, thus transforming these into dry batteries. An advantage of these laurostearate cells is that the electrolyte is very cheap, and is often used to adulterate certain soaps. The batteries are absolutely dry, and, compared with ordinary dry cells, they are equal in power. There is no local action, because a layer of gray oxide forms upon the zinc plate and protects it from the electrolyte. M. Buffa has constructed an accumulator on this principle. It is of the tray type, being formed of small trays piled one above the other. Each tray contains a layer of zinc amalgam in a semi-liquid form. This is the negative electrode. On the amalgam is placed a layer of laurostearic soap, prepared as described. This layer is a few millimetres in thickness. Upon the soap is placed a layer of the depolarizing material. This is merely a paste formed of the soap itself and some peroxide. These trays are piled up so that the bottom of each comes in contact with the depolarizing paste in the one below. The trays themselves may be of a number of materials, iron being very satisfactory. This apparatus has been found to be very convenient.—*Bulletin de la Association des Ingénieurs Electriciens.*

Trial of a 240-Horse-Power Diesel Oil Engine.

Tests were recently made of a 240-horse-power Diesel oil engine at the makers' works in Ghent, Belgium. The engine was of the inverted vertical type, with three cylinders and three cranks set at 120 degrees. It was intended to measure the power developed, but the brake used was insufficient for the work, and the results given in this article by Mr. Longridge, who conducted the work, are based on the indicated horse-power. The cycle of this engine consists of four strokes. During the first down-stroke air at atmospheric pressure enters the cylinder. Upon the next up-stroke this air is compressed to something over 500 pounds per square inch, and the temperature is thus raised sufficiently to ignite the oil, which is sprayed into the cylinder during the next down-stroke by means of a jet of air taken from a reservoir where the pressure is maintained at about 800 pounds per square inch. The oil ignites and burns, maintaining the initial pressure until combustion is completed. This is followed by expansion to the end of the stroke, and on the following up-stroke the contents of the cylinder are expelled. The fuel used was crude Texas oil. The calorific value, computed from the chemical constituents, was found to be 18,860 British thermal units per pound; that found from a Berthelot-Mahler bomb calorimeter was 18,900 British thermal units. Deducting from this the heat of evaporation of the water formed during the process of combustion, the available calorific value was 17,770 British thermal units per pound. During several of the tests, samples of the expelled gases were taken and examined chemically. They showed about 7.25 per cent of carbon dioxide; from nine to ten per cent of oxygen; about eighty-three per cent of nitrogen, and a trace of hydrocarbon. These figures show an excess of nitrogen, which is attributed by Dr. Bone, who made the examination, to an incomplete combustion of the oil. He believes part of the oil suffered purely thermal decomposition, or possibly partial and non-explosive combustion before the mixture of oil and air became ignited in the cylinder. The results of four tests are given. In that showing the best performance, the indicated horse-power, corrected, was 285. The mean effective pressure on all pistons was 95.6 pounds per square inch. It was approximately the same on all three pistons. The heat account for this performance is as follows: the calorific value of one pound of oil is taken as 17,770 British thermal units; the heat equivalent of the work done was 7,606 units, being 42.8 per cent of the whole; the heat carried off in the jacket water was 4,580 units, or 25.8 per cent; that lost in the exhaust gas was 5,720 units, being 32.2 per cent of the total. This leaves a negative loss unaccounted for of 136 units, or about 0.8 per cent. As there is very little loss due to radiation—all of the cylinders being jacketed—this discrepancy is probably due to unavoidable errors in the test.—*Mechanical Engineer.*

Convention of the Illinois State Electric Association.

The annual convention of the Illinois State Electric Association was held at Decatur, Ill., October 5 and 6. The hotel St. Nicholas was made headquarters. The official headquarters was at the office of the Decatur Railway and Light Company, and the meetings were held in the same building in the Elks' clubrooms. On the evening of October 5, the visitors were entertained at the Opera House, and all business was concluded by noon on October 6. Special cars took the party on an inspection trip over the new interurban road from Decatur to Springfield, and an inspection was also made of the Riverton power plant.

Electric Railways in Scotland.

United States Consul Rufus Fleming reports that the town council of Leith, Scotland, has acquired the horse-car lines within the borough from the private company which has heretofore operated them. It is purposed to construct the lines, and the single-wire overhead trolley system will be recommended for adoption. The plans proposed contemplate the use of centre poles erected in the middle of the street. The length of the line is a little over five miles.

Stoves in Trolley Cars.

The Public Service Corporation, of Newark, N. J., has begun the installation of ordinary stoves in all of its cars, and expects to use them exclusively for heating purposes during the coming winter; electric heating and hot water systems having proved neither satisfactory nor economical.

"NEGATIVE" BOOSTERS.

BY J. STANLEY RICHMOND.

In order to logically consider this and eral other questions, the writer has nd, as a result of some very thorough estigations and by dealing with elec- al metaphysics in a somewhat origi- way, that it is absolutely impera- e that all electrical phenomena should looked upon as the result of differences ween different points of a certain con- ion of matter; which condition, for con- ience, may be termed its electrical con- ion; and that the expressions voltage, ential and direction of transmission uld be so clearly understood that they ll always be correctly applied and there- prevent confusion. For voltage is the ree of intensity of electrical condition one point only, while potential is the ference between the voltage of one point d the voltage of another point. Direc- n of transmission, being self-explana- y, requires no definition.

It is also advisable, perhaps, in order t the reader may easily follow and as- ilate the diagrams and arguments ich will be used, to recall to his memory e elementary information, probably re- ved in his school-boy days, by defining n clear and simple manner the meaning the word zero. For, in the systematic sideration of any condition of matter, is requisite to have a starting point ich is so termed in order to argue clear- and to measure correctly and compara- ely.

That absolute zero signifies nothing is erally known. When one deals with mething, therefore, such "something" is lus quantity to "nothing" or absolute ro. As it is often impossible to obtain absolute zero, it becomes necessary to opt a known plus condition as an arbi- ry zero; and, if possible, such should ays be to absolute zero the same amount as.

Such an arbitrary zero is just as neces- y for electrical measurements, in many es, as it is in temperature measure- nts. Unfortunately, however, the pres- t state of knowledge in regard to elec- al metaphysics is such that a standard bitrary zero can not be adopted. The ltages of different points of the earth er a somewhat circumscribed area are proximately equal, however, during con- ions of inoperation of earthed electrical nt. The normal voltage of the earth ring operation, therefore, is the most isfactory arbitrary zero that can at pres- t be obtained.

It may be incidentally stated that it is necessary for convenience to sometimes use, besides absolute zero and arbitrary zero, two other zeros designated, respectively, self-zero and medial-zero; self-zero being the voltage of the point in a generating and transmission medium having the lowest voltage and medial-zero the voltage of the middle points electrically of such.

In the issue of the ELECTRICAL REVIEW, August 30, 1902, appeared an abstract of a lecture on the "Electrolysis of Gas Mains," delivered, if correctly understood, before the members of the Gas Institute of Great Britain, a portion of which reads as follows: "taking the earth itself generally as being at zero pressure, or to use the water analogy, at zero level or head, we may consider that one end of the rails would, in the extreme case mentioned, be fifteen volts above the zero, and the other fifteen volts below."

A very important factor, apparently lost sight of when the lecturer expressed such opinions to the members of the "institute," is (while the earth has its electrical condition over a given area, such as that over or through which an average traction system is operated, more or less equal at all points during inoperative conditions) that the electrical condition or voltage of the earth contiguous to the earthed return of a traction system during operation varies from point to point, the voltage of each point being more or less controlled by the nearest portion of the return. To have a portion of the earth, of any practical dimensions in so far as the question at issue is affected, at a lower voltage than normal (arbitrary zero of the district) would require, to commence with, that the low-voltage pole of the generator should have a much lower voltage than such arbitrary zero, and then that a considerable amount of metal forming a portion of the return should be earthed from the low-voltage pole to the point of the return having arbitrary zero voltage, to obtain which two factors combined is an impossibility—if one considers plant as illustrated by the lecturer.

Extensive experiments carried out by the writer have proved that the voltages derived by portions of the earth or earthed auxiliary conductors, as a result of the operation of grounded returns, depend, somewhat, upon the amount (surface) of uninsulated grounded metal in their immediate vicinity. One experiment [conducted at a point in a river about one-quarter of a mile distant from a power-house, when such point of the river was about ten volts higher than the low-voltage pole of the machine (self-zero of the system)] was somewhat as follows: one end of a 500,000 circular mils insulated cable was connected to the low-voltage busbars and the other end to a built-up circular collector plate having a surface, approximately, of 900 square feet. The plate was lowered into the water, so that it rested on the river-bed. As a result, the plate had a voltage equal to the self-zero of the system, while the water at a distance of only some twenty or thirty feet away remained at its usual abnormal voltage; that is, two points of the water situated some twenty or thirty feet apart showed a potential of about ten volts. The information so obtained agrees with the fact that if the low-voltage pole of a motor is connected to a ground plate and the other pole to a trolley wire of an earthed system the motor will not "turn over." It is important, in connection with the descrip-

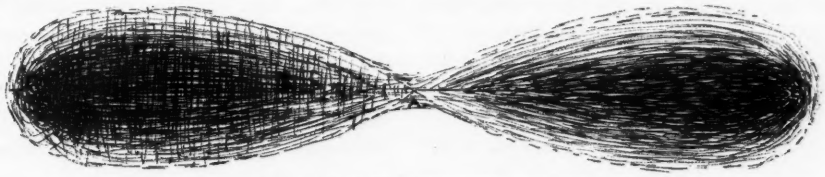


FIG. 1.—VOLTAGE CONDITIONS ASSUMED.

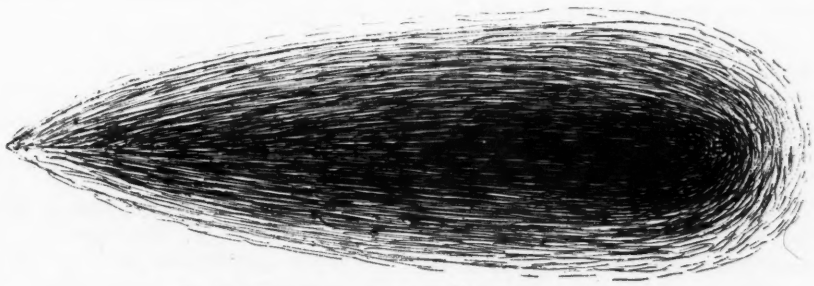


FIG. 2.—CONDITIONS OF ABNORMAL EARTH VOLTAGE.

tion of this experiment, that the fact should be mentioned that the self-zero was below the arbitrary zero, owing to the fact that a considerable length of insulated cable connected the rail-return to the low-voltage bus-bars, the theories in connection with which will be explained later.

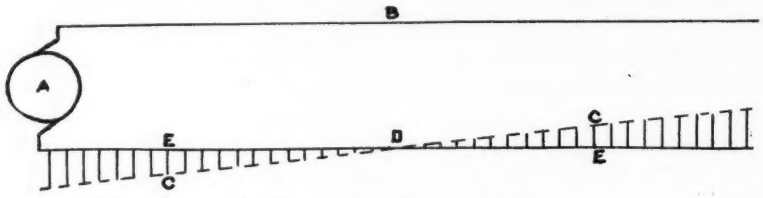


FIG. 3.—GROUND RETURNS.

Another experiment consisted in the breaking of a rail-return at two points about one-third of a mile apart by removing the fish-plates and springing apart and raising the rail-ends, so that a portion of the track about one-third of a mile long was insulated (except by contiguous earth paths) from the remaining track. When a car at full load was near one of the breaks, a potential of ten volts was obtained between the end of the insulated portion of the track and the end of the rail-return from which it was insulated (track running to the power-house), which potential gradually decreased as the car receded from the break until it became almost nil when the other break was reached. Incidentally, it may be said that the break at both ends appeared to cause no practical interference with the operation of the car. These two examples, though apparently contradictory to each other, support, as will be understood later, the criticisms which will be made on the lecturer's opinions diagrammatically illustrated in Fig. 3.

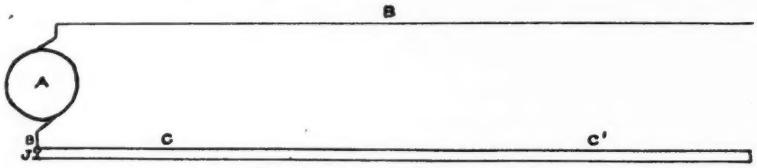


FIG. 4.—GROUND RETURNS.

Fig. 1 is a chart illustrative of voltage conditions such as assumed by the lecturer. Now to obtain such conditions would require two generators connected in series with the middle point between them (junction of one pole of one machine with one pole of the other machine) grounded to the rail at A; and the outside pole of each machine connected the one to the trolley wire feeding the section having the conditions represented in the chart from A to C and the other connected to the trolley wire feeding the section similarly represented from A to B. The two trolley wires, of course, would have to be insulated from each other. The cross-section shading would then represent voltage conditions lower than and the straight shading that of the voltage conditions higher than zero (arbitrary zero voltage of the district). The depth of the shading, in both cases, would represent the degree of the earth voltages below or above such zero. No shading, of course, would represent zero voltage. A chart representing the conditions of abnormal earth voltage which would actually result (from the operation of such a plant installation as was assumed by the lecturer for explanatory purposes) would be as shown in Fig. 2; in which A is the point of connection between the low-voltage pole of the generator and the home terminal of the rail-return, while B is the further end of the same return.

Apropos of the foregoing, consider the lecturer's diagram marked Fig. 3, which is the foundation for the remaining diagrammatic illustrations used by him in the consideration of the application of negative boosters to grounded returns. Now it is perfectly reasonable to assume that the accuracy of not only the following diagrams, but also his explanations of and deductions from such will, in the main, depend upon the accuracy of the fundamental principles and reasoning accepted by him and involved in the de of this diagram.

Fig. 3 is a reproduction of his Fig. in respect to which he explains that E the return and that its potential with gard to the earth is represented by dotted line CC; and that the rails "positive" at the far end, while, at near end, they are "negative." Analy this means that CC represents the volt of different points of the rails (rail-dr and EE the voltage of different points the earth or accidental auxiliary retu (earth-drops or pipe-drops). A car consideration of the diagram will sh that the conditions stated by him as ex ing and therein represented can only l to the conclusion that his findings w hardly correct. For it is impossible have, if the definitions before given voltage and potential are remembered, point having a difference of voltage equi lent to the greatest difference of volt existing at any part of a system betwe an earthed track return and some of accidental auxiliary conductor, though will be noticed, his chart represents no a difference of voltage as existing at point where the rail return is connec to the low-voltage side of the generat As an illustration of such analysis, co sider, in the diagrammatic sketch of plant, marked Fig. 4, that A represent generator with its low-voltage pole B co nected directly to J, the home termin of the rail CC'. Let J and B be connec to earth. So, as there is, practically spe

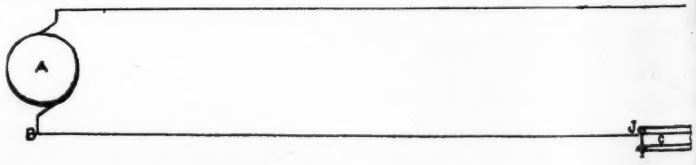


FIG. 5.—GROUND RETURNS.

ing, no length of cable connecting J B, the voltage of J and B will be equ that is, as the earth or earthed auxilia returns (contiguous to such point of co nection) derive their abnormal volta from the earthed return, it follows th

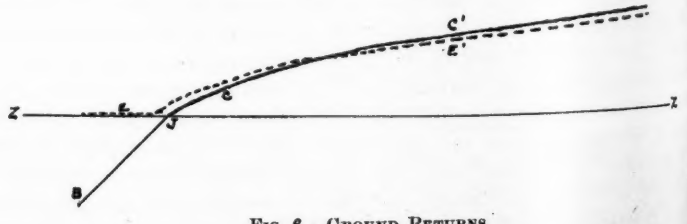


FIG. 6.—GROUND RETURNS.

such derived abnormal voltage of the ea in the neighborhood of J and B must about equal to or, to allow the worst, b very slightly higher than that of J and

In Fig. 5 the plant installation illu

ed is the same as that represented in 4, with this exception, that the home minal J of the rail C is connected to low-voltage pole B of the generator greater or lesser length of insulated e, the drop along which cable, it may ssumed, amounts to fifteen volts. As

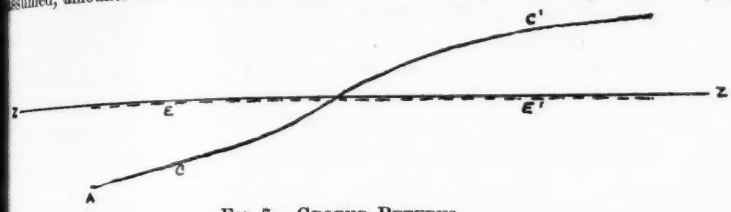


FIG. 7.—GROUND RETURNS.

sult, the low-voltage pole of the gen- or will, approximately, be fifteen volts r than the arbitrary zero voltage of District, which arbitrary zero will, ap- ximately, be equal to that of the voltage he rail at the point J.

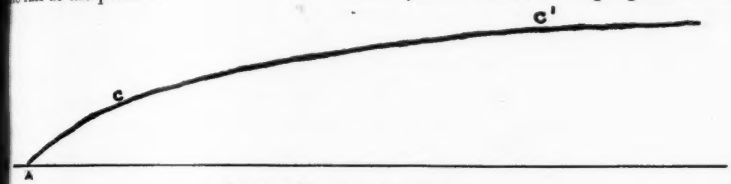


FIG. 8.—GROUND RETURNS.

curve showing the voltages of the lar track return and accidental auxil- earthed returns, as a result of plant pment such as is represented in Fig. ill be somewhat as in Fig. 6; in which, being the zero line, J is the voltage he terminal J of the rail, CC′ is the

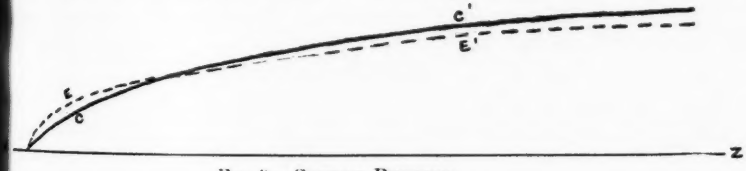


FIG. 9.—GROUND RETURNS.

ge of different points of the rail-re- (rail-drop), EE′ is the voltage of rent points of the accidental auxiliary rns (earth-drops), J to B is the volt- at different points of the return feed- from the rail-return to the generator

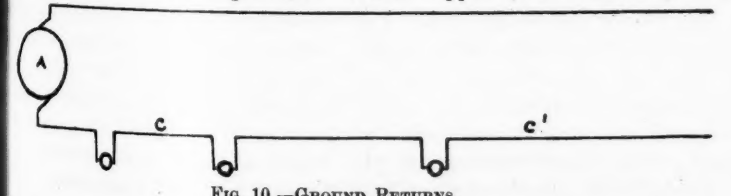


FIG. 10.—GROUND RETURNS.

urn feeder drop) and B is the voltage e low-voltage pole of the generator. ow if, as the result of plant installa- such as is represented in the lecturer's ram, voltages existed such as therein hically shown, such voltages would to be diagrammatically illustrated somewhat as shown in Fig. 7; in which, ZZ′ being the zero line and A the voltage of the low-voltage pole of the generator, CC′ would represent the voltage at different points of the rail-return (rail-drop) and EE′ the voltage at different points of the accidental auxiliary returns (earth-drop, pipe-drop, etc.). Those who have been engaged on investigations connected with the problems which arise in dealing with the question at issue can easily understand, though, that such plant installation (as he allowed for purposes of illustration) could not produce conditions of voltage such as he assumed; and, also, that such assumed conditions of voltage, even if they were correct, could not be correctly illustrated by the diagrammatic principle adopted by him.

To support such statements, consider plant installation such as he assumed; that is, an installation having the rail-return (track) connected to the low-voltage bus-bars by a negligible length of cable and that, as in his illustration, no auxiliary return copper (return feeders) are installed. Turning to Fig. 4 again and to somewhat reiterate, CC′ will represent the rail-return (track) with its terminal J nearest to the power-house connected to the low-voltage pole B of the generator—by way of the bus-bars, of course. Now (as the voltage of such pole is the self-zero of the system, and as the terminal of the rail-return is connected to such pole, and as such pole and terminal are earthed—due to the rails from such point outward being all earthed—and as the voltages of the different points of the rail-return are derived from the voltages of the low-voltage poles of the motors, which motor voltages are higher than the arbitrary zero of the district) it follows that the arbitrary zero and the self-zero will, practically speaking, agree; that is, be about equal. A curve to diagrammatically represent, in this case, the voltage of different points of the rail-return will, therefore, have to be plotted as in Fig. 8; in which, ZZ′ being the zero line, CC′ is the required curve to correctly illustrate such voltages. And, in the same case, to correctly represent by a diagram the voltages at different points of the earthed accidental returns (earth-drops, pipe-drops, etc.) necessitates that the rail-drop curve should be plotted first (as in Fig. 8) and then that the earth-drop should be plotted on such rail-drop curve—as shown in Fig. 9—in which, ZZ′ being the zero line and CC′ the rail-drop curve, EE′ represents the voltage at different points of the earthed accidental returns (earth-drops). The space between E and C, therefore, represents the danger area, while that between C′ and E′ represents the non-danger area.

As is generally known, the English Board of Trade has among its rules and regulations applying to the operation of grounded returns of "tramway" (street railway) companies one which reads as follows:

"7. When the return is partly or entirely uninsulated, a continuous record shall be kept by the company of the difference of potential"—difference of voltage—"during the working of the tramway between the points of the uninsulated return furthest from and nearest to the generating station. If at any time such difference of potential"—difference of voltage—"exceeds the limit of seven volts, the company shall take immediate steps to reduce it below that limit."

Now, while the regulation is not elastic enough to suit, in all fairness, every road using earthed returns, it is a good provision and can be lived up to in the majority of cases without any financial hardship—provided that modern approved engineering practice is rightly applied by them in respect to local conditions.

Unfortunately, however, the engineering principles affecting the question and application of grounded returns have not received from engineers the attention due them; in fact, the principles followed up to date have mostly been of the "penny

wise and pound foolish" order. The financial "end" of the companies is not to blame. For they rely on the engineering "end"; which end, unfortunately, has, while developing other portions of traction plant to a state of efficiency deserving of the utmost credit, apparently considered that anything was good enough for the return, neglecting in many cases to even keep up to standard the condition of the rail-return from a conductor point of view. As for auxiliary copper, such has been considered as something only to spend money on if outside parties were able to force the expenditure for such. So many companies, believing that auxiliary copper is a dead loss as an investment—which it is not—endeavor to live up to this regulation in the "letter," but not the "spirit of the law" by using negative boosters.

In so far as negative boosters are concerned, consider, first, the case when they are inserted in series with the rail-return, as illustrated in Fig. 10.

(To be concluded.)

Convention of the New England Water-Works Association.

The New England Water-Works Association held its twenty-first annual convention at Holyoke, Mass., September 14, to 16. The headquarters were at the Hotel Hamilton, where the technical papers were read and business transacted. Part of the time was spent in sightseeing, for which many local manufacturing concerns contributed facilities, including the Coburn Trolley Track Company, the Holyoke Water Power Company and the Deane Steam Pump Company.

The latter company contributed much to the pleasure of the visiting delegates by providing a large Knox touring car, which was used, not only to convey the visitors to the Deane steam pump works, but also for many other trips. One of the latter was a ride to the Ashley pond reservoir, the new high-service reservoir and the Whiting street reservoir, giving the water-works engineers an excellent opportunity to inspect the work in connection with the high-service reservoir.

The visitors to the Deane works were entertained by Mr. Chas. L. Newcomb, manager, and this company also maintained a large reception room at the Hotel Hamilton where all visitors were cordially welcomed by Messrs. C. B. Moore and A. M. Pierce, of the Deane company's Boston office.

Henry R. Worthington, of New York, also established headquarters at the hotel under charge of Mr. Samuel Harrison, special meter salesman. The exhibit of meters included the well-known Worthington duplex meter and also that company's disc, hot-water and oil meters. A novel and useful application of meters has recently been introduced by this company, *viz.*, the use of meters for measuring compressed air.

THE PRIME MOVER SITUATION.

TO THE EDITOR OF THE ELECTRICAL REVIEW:

We note in your issue of September 17, an article by Dr. Louis Bell in regard to "The Prime Mover Situation," and in reply would say that we would like to call to his attention a remark of his to the effect that "perhaps there is not an equal example of such remarkable machines in this country." Would say that we are enclosing a copy of a test on a compound engine, on condition similar to those that he states, giving results better than ten pounds of steam per hour. This subject of superheated steam has already been taken up here to a considerable extent by this company, and in the development of the superheaters we feel that we have solved the question of obtaining high superheat beneficial in engines, having either the ordinary piston or slide valve, of the three-cylinder type, results of tests on which he mentioned in a preceding paragraph. This test was one that the writer had been acquainted with, due to his visit on the other side this summer (made upon a Willans engine of 200-horse-power). Both this test and the test that is described in the pamphlet we send you were made with the assistance of a Schmidt type of superheater, which we have been manufacturing for three or four years. We trust that this will put us in a fairer position, which we feel was not quite so without this answer.

RANDOLPH T. ODE, Secretary,
Providence Engineering Works.
Providence, R. I., September 22.

[The test referred to in the above letter was made by Professor D. S. Jacobus on a compound Rice & Sargent engine. The bore of the cylinders was 16.07 and (28.03) inches. The length of stroke was forty-two inches. The high-pressure cylinder was fitted with double dead-beat poppet valves; the low-pressure cylinder with Corliss valves. The pressure of steam at the engine throttle was slightly over 140 pounds per square inch. The superheating at the same point varied from 350 to 400 degrees Fahrenheit. The vacuum, measured near the engine, ranged from twenty-five to twenty-six inches of mercury. The water consumption per hour per indicated horse-power was 9.76 pounds with an indicated load of 474.5 horse-power; 9.56 pounds at 420.4 horse-power, and 9.70 pounds at 276.8 horse-power. The heat consumption per minute per indicated horse-power, according to the standard recommended by the civil engineers of London, where the engine is charged with the heat in the steam in the throttle valve, and is credited with returning the feed water to the boiler, the maximum possible temperature that could be obtained by a feed water heater in the exhaust valve, was 205 British thermal units at 474.5 horse-power; 206 British thermal units at 420.4 horse-power, and 208.8 British thermal units at 276.8 horse-power. With saturated steam the water consumption was 13.84 pounds per hour per horse-power at 406.7 horse-power, and the heat consumption was 2,448.2 British thermal units per indicated horse-power. During this test the vacuum was only 24.5 inches of mercury. The performance of this engine is certainly highly creditable to its designers and builders. It should be mentioned that the test was made, not at the works, but at the Milbourne Mills, Philadelphia, Pa., where the engine had been installed. ED.]

Electrolysis of Water Mains.

In the last report of the Metropolitan Water and Sewerage Board, of Boston, the following points are noted: On nine linear feet in a forty-eight-inch pipe in Cambridge, 5,225 pittings were located, varying in depth from one-sixteenth to five-eighths of an inch. In parts of the lines of thirty-six-inch cast-iron pipe under the Charles river eleven pittings from two to six inches in diameter and three-eighths to three-fourths of an inch in depth were found. The pipes in the river are being destroyed very rapidly. At other river crossings damage was noted. In the city of Chelsea a twenty-four-inch cast-iron pipe line in 280 square feet of pipe surface showed 250 pittings from one-sixteenth to nine-sixteenths of an inch deep. In Lynn on 175 square feet of the surface of a twelve-inch pipe were found 387 pittings from one-thirty-second to seven-sixteenths of an inch in depth, and at another place over an area of four square feet were found 200 pittings. The deepest of these was 0.45 of an inch with but 0.24 of an inch of the original thickness of the pipe left. A large portion of these pipes will have to be replaced. An insulating joint with a connection made of a rubber gasket 0.5 inch in thickness placed between two flanges, has been found helpful in preventing the flow of a large amount of electricity from the Metropolitan pipes to those of the city of Cambridge.

Meeting of Connecticut State Street Railway Association.

The Connecticut State Street Railway Association will hold its annual meeting in November. Mr. E. W. Poole, of Bridgeport, is secretary of the association.

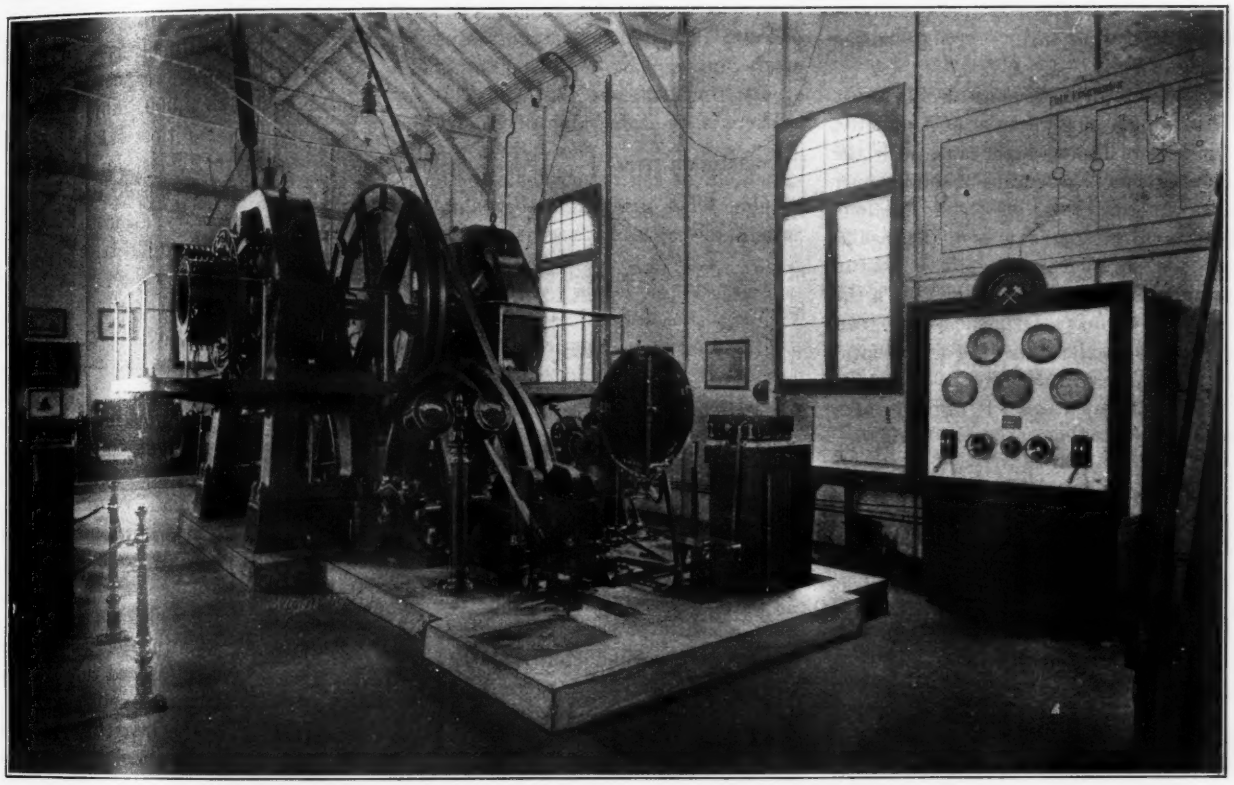
ELECTRICALLY OPERATED HOISTING ENGINES.

BY EMILE GUARINI.

The use of electricity in mines for ventilating, hauling, transportation, and particularly for draining, has extended greatly, but there are yet few applications of this power to mine hoisting. In the greater number of mines where electricity was tried for this purpose, the electrical control of the hoisting engines was defective, and there has been a general belief that electric machines are not sufficiently reliable, and that they are not economical when compared with steam winding engines. This idea has possibly been justifiable, but it is not at present. Now electrical control of these machines has made considerable progress, which is explained by the advantages which this method presents. The ease of operation is greater than with steam engines, while the consumption of steam and of coal is considerably less. The loss of energy and the wear are less, and the consumption of oil and grease and of coal is reduced to one-half. The manipulation is simpler, the first cost less burdensome, and, finally, the use of a storage battery allows of the storing up of energy during the descent of the car, something that is impossible when steam is used.

In order to obtain these excellent results it has been necessary to find means of coupling directly the motor and the winding drums, a method of starting gradually, of delicately grading the speed, and of rendering the service as simple and as safe as possible. This interesting problem has been solved in a noteworthy manner in the hoisting engine constructed by Schuckert & Company, of Nuremberg, whose apparatus is shown in the accompanying illustration. The machine is designed for raising from a depth of 400 metres two cars, each carrying a useful load of 700 kilogrammes, at a speed of fifteen metres per second. It consists of three friction drums two and one-half metres in diameter. The lower two drums are each provided with a double brake, which can be operated, first, by compressed air or by a weight released by the foot; second, by a safety device which operates whenever a certain speed is exceeded; third, by the demagnetization of an electromagnet which takes place when the motor-current is interrupted, and thus releasing a weight. Starting of this machine is possible only after the brakes have been released. It is carried out by a control lever similar to that used with a steam machine. The installation is further provided with electric signals, a speed-controller, a retarder, etc.

The winding engine is operated by two continuous-current motors of 200 horsepower, making 115 revolutions at 500 volts. A special arrangement allows the speed to be varied. In this arrangement the counterelectromotive force opposed to the supply is gradually diminished as the speed of the motors increases. This method has the great advantage of avoiding energy loss due to resistances. The operation is simple, as the man in charge need only manipulate the starting and braking levers, while watching the depth indicator and the tachometer. These machines have been installed in a number of mines in Europe.



MINE HOISTING ENGINE, OPERATED BY TWO CONTINUOUS CURRENT 200-HORSE-POWER MOTORS.

Electric Towing on the Erie Canal.

The committee appointed to investigate towing problems on the Erie canal, at its meeting in Albany, recommended that inventors be invited to design a towing system for the enlarged canal, and that a committee be appointed to examine the devices submitted. The committee was divided on the question as to whether it should be made imperative that any system proposed be applicable to the entire length of the canal, the contention being that on account of the varying nature of different sections more than one method of propulsion might be advantageous.

INSULATING MATERIALS IN HIGH-TENSION CABLES.[1]

BY E. JONA.[2]

We have now in operation plants working at fifty to sixty kilovolts, with aerial lines. It is said that some will be installed at eighty kilovolts or even higher, but I do not believe that there is any manufacturer ready to furnish cables for such high tension, although, of course, every manufacturer has occasionally had samples of cables tested as high as 100 kilovolts, without perforating them.

Let us take a glance at the conditions in manufacturing such very high-tension cables.

First, as to some theoretical difficulties. Let us suppose for the sake of simplicity, a single-core lead-covered cable with the following data: r = radius of solid copper wire; s = thickness of the insulation; $r + s = R$ external radius of the insulation. An alternating current is flowing through the cable, at a tension V. In the limits of ordinary frequencies, we can speak of potential, and use the electrostatic laws in any section whatever of the cable. The potential at a point P (Fig. 1) at a distance ρ from the centre will be then:

$$v = V \frac{\log \frac{R}{\rho}}{\log \frac{R}{r}} \qquad (1)$$

Differentiate (1) with respect to ρ, taking decimal logarithms, and we get:

$$\frac{dv}{d\rho} = \frac{0.434\ V}{\rho \log \frac{R}{r}} \qquad (2)$$

$\frac{dv}{d\rho}$ is the gradient of the potential, or its variation along the radius. If we refer the dielectric strength of materials to the millimetre as a unit of thickness (and assume for example that a given material can stand 10,000 volts per millimetre thickness) and express our formula in millimetres, $\frac{dv}{d\rho}$ will be the puncture stress on the dielectric per millimetre at the point considered. It must be less than the dielectric strength in order to have a breakdown; in our example, it must always be less than 10,000 volts per millimetre.

In the formula (2) putting $r = \rho$ we have

$$\left(\frac{dv}{d\rho}\right)_r = \frac{0.434\ V}{r \log \frac{R}{r}} \qquad (3)$$

This is the stress on the small dielectric layer immediately surrounding the inner conductor. For $\rho = R$

$$\left(\frac{dv}{d\rho}\right)_r = \frac{0.434\ V}{R \log \frac{R}{r}} \qquad (4)$$

the stress on the small dielectric layer near the outer lead.

It is to be remarked that the stress is greatest in contact with the conductor, and minimum in contact with the outer lead; and the latter is precisely equal to the former multiplied by R. r is generally very small in high-tension cables, and R very large. There is thus a very great difference in the stress on the different small dielectric layers, the most internal of which must support a tension three, four or five times that of the external layer.

There is a certain value of r for which the maximum stress $\left(\frac{dv}{d\rho}\right)_r$ is as small as possible for a given R; we obtain this value of r by equating to zero the derivative of $r \log \frac{R}{r}$ with respect to r. Hence we have:

$$r = \frac{R}{e} = \frac{R}{2.71} \qquad (5)$$

FIG. 1.—POTENTIAL AT POINT P.

I shall consider later the very frequent case where the conductor is not a solid wire, but a stranded one, and the relative formulas for any stranded conductor.

These brief considerations point to the conclusion that doubling the thickness of the dielectric by no means allows of doubling the dielectric stress on the cable; for the strength increases much less than the increase of thickness. Practically, for the sake of manufacturing, handling, etc., we can not use too great thicknesses, especially if we consider also the weight of lead and armoring. If we admit that a homogeneous dielectric in a cable is punctured as soon as the stress surpasses in some point the dielectric strength, we see immediately the enormous advantage of using materials of very high specific strength. In fact, if we can with safety allow the material to be worked at w volts per millimetre, the formula (3) gives us immediately the thickness required.

$$w = \frac{0.434\ V}{r \log \frac{R}{r}} \text{ whence } \log R = \frac{V}{r\ w} 0.434 - \log r \qquad (6)$$

This formula tells us that R diminishes rapidly by augmenting w.

A numerical example will illustrate this better. Let r = 10 millimetres and V = 20,000 volts; and suppose we have at our disposal an insulating material able to stand 12,000 volts per millimetre and another for only 8,000 volts per millimetre. Let us take the same factor of safety, say, one-fourth, in both cases; that is, we work at a maximum of 3,000 volts per millimetre for the former, and 2,000 volts for the latter.

In the first case we ought to have a thickness of 9.45 millimetres and in the second 17.20 millimetres. The volumes of the insulation are respectively 875 cubic millimetres and 2,000 cubic millimetres; they are in the ratio of 1 to 2.28 while the ratio of the dielectric strengths is as 1: 1.5. In this example the volumes of the insulation vary almost inversely as the squares of the dielectric strength.

In a 40,000-volt cable, with r = 10, and w = 3,000 V per millimetre, we ought to have an insulating thickness of sixty-six millimetres; that is, a thickness impossible in practice. We see that, in this case, doubling the working tension compels us, *caeteris-paribus*, to use seven times the previous thickness. Hence it is obvious that it is not possible to manufacture 40,000-volt cables, with a material working with safety only to 3,000 volts per millimetre.

Two insulating materials are now principally competing in the field of high-tension cables—vulcanized rubber and paper impregnated with rosin and oil mixtures. Both have their partisans and their opponents. Paper insulation has made great progress in the last few years. The utility of using good manilla paper, laid on in thin and regular layers, without wrinkles and crumpling, has been recognized, and also the utility of having it properly dessicated, at a moderate temperature, in a vacuum, and impregnated with a compound of rosin, or wax, or asphalt, with mineral, or castor, or linseed, or some other oil, that does not become brittle or pulverize with age. But rubber also has made progress; and if some feared formerly that it could decay with age, it is now certain that first-class rubber cables, well vulcanized and removed from the influence of brush discharges in the air, or not alternately dry and wet, will last indefinitely.

Rubber has a dielectric strength much higher than impregnated paper. Testing good rubber cables in such lengths as to include the inevitable irregularities of

[1] Presented before section E—electric light and distribution—at the International Congress, St. Louis, 1904.
[2] Delegate of the Associazione Elettrotecnica Italiana.

manufacture, with tensions progressively increasing and subjected to dielectric strain at least one hour, we can easily obtain for the rubber a dielectric strength of twelve to fifteen kilovolts per millimetre. Paper in the same conditions would only stand eight to ten kilovolts per millimetre. These numbers represent as good an average as we can reach in normal manufacturing; it is not rare to find twenty to thirty per cent more, or even higher percentages, but we can not reckon upon these. The higher dielectric strength of rubber brings us to the conclusion that the use of rubber for very high tension will extend more and more.

A cause of inferiority of the rubber is the lesser homogeneity of its products. It is not uncommon to find that two cables manufactured in the same manner, with the same quality of rubber, afford a very different resistance to perforation—a difference, say, of thirty to forty or fifty per cent. Paper cables are more homogeneous. The figures relative to dielectric strength given above are the result of a great number of tests made by the author on cables of various makers. They do not take account of some exceptionally high strengths; I found some pieces of rubber cable to withstand twenty to twenty-five kilovolts per millimetre. The elasticity of rubber gives it a great superiority over paper. A paper cable with large thickness of paper can not be easily bent, especially in cold weather, owing to cracking; on the other hand, the manufacture of concentric, or stranded, multiple-core cables is simpler in the case of paper cables, for the insulating material can be uniformly distributed in the interspaces among the conductors, which remain buried in the insulator, which is not possible with rubber.

The great success of paper cables is a consequence of their lower price. But very high tensions require such a greater thickness of paper, that the cost of the paper added to the extra price for the larger quantity of lead, steel, tape, etc., permits the rubber to win in the competition.

The problem of manufacturing high-tension cables would be simpler if the gradient of the potential within the body of the insulator was constant. Suppose a thirty-eight square millimetre cable insulated to 14.5 millimetres outer diameter, and working at 25,000 volts. The layer near the copper supports a strain of 5,000 volts per millimetre, while near the lead the stress is only 1,200 volts per millimetre. Should the stress be constant throughout, each layer of one millimetre would support a strain of 2,270 volts, and the cable would be much safer. We could then also diminish the thickness of the insulation to, say, five millimetres, letting every layer work at 5,000 volts.

This ideal condition of uniform gradient we can seek to reach in practice. A similar proposal was made by Mr. O'Gorman in a highly interesting paper, read before the Institute of Electrical Engineers, London, in March, 1901; but it is difficult to imagine how Mr. O'Gorman's system can be practically applied. It consists chiefly in imbedding the layers of paper more or less in some oils (like castor oil) according to their distances from the centre; so that the inductive capacity of any layer is in inverse ratio to these distances.

Without claiming to get an absolutely constant gradient, we can, therefore, try to have the potential better distributed along the radius of the insulation, and at the same time use in the proper place materials having greater dielectric strength, by making the insulating layers of different materials specially chosen. This method I studied and applied to the manufacture of high-tension cables, as early as 1898. Such cables, consisting of conductors first insulated with several layers of rubber, on which were wound layers of paper or jute, were patented by Messrs. Pirelli & Company, March, 1900. A cable of this kind was working at 25,000 volts, during the Paris exhibition of 1900.

The specific inductive capacity of paper cables varies from 3 to 4, according to the type of paper and mixture adopted. The inductive capacity of paper is about 2; that of rosin 2 to 3, according to its origin; and mixtures of rosin, oil, paraffin, ozokerite, and other materials, have a capacity of 3 to 4, or even more. For example, lubricating oil 55 parts, rosin 560, paraffin 224, ozokerite 160, has a standard inductive capacity of 3.6; oxydized linseed oil 90, rosin 370, Arkangel pitch 70, have 4.4; Arkangel pitch itself has 5.9; a mixture with Gallipot, instead of rosin—for example, Gallipot 600, Arkangel pitch 110 and linseed oil 130—has 4.8; a mixture of lubricating oil 9, rosin 52, black ozokerite 23, white ozokerite 16, has only 3.55.

It appears from these figures that it is possible to have a large range of inductive capacity with paper cables. But as they are impregnated in mass, the entire mass has the same standard inductive capacity unless we change the type of paper, by using, for example, paper loaded with some materials, as suggested very ingeniously by Mr. O'Gorman; but I do not know if he succeeded in doing so. On the contrary, it is easy to use different rubbers having varied standard inductive capacity, for rubber is put on in successive layers which can be quite different one from another, and which have no tendency to mingle together, either during or after manufacture. The cables I alluded to are manufactured with layers of various qualities of rubber in the inner part of the insulation; but as soon as the gradient of potential becomes so diminished as to allow the use of paper, the insulation is continued with paper, and after the paper with jute, if the gradient is sufficiently low to allow the use of jute. The rubber insulation is generally first vulcanized and the conductor tested in water, as usual, before adding the outer layers of paper and jute.

Pure vulcanized rubber has an inductive capacity something like three as an average; but it is very easy to "load" the rubber with large quantities of extraneous materials, which, without sensibly lessening its specific dielectric strength, augment the capacity very much. A rubber with fifty-eight per cent para, two per cent sulphur, twenty-six per cent talc and fourteen per cent oxide of zinc, has a dielectric strength comparable to that of pure vulcanized para (fifteen to twenty kilovolts per millimetre); and a specific inductive capacity of 4 to 4.2. A rubber with sixty-four per cent para, eight per cent sulphur, sixteen per cent talc, eight per cent minium, four per cent oxide of zinc has about the same dielectric strength as above mentioned, while its specific capacity reaches five. A rubber largely loaded with sulphur and talc, for example, para 100, talc forty, and sulphur forty, has a capacity as high as 6.10, with a dielectric strength of the same order of magnitude as before. A mixture of para forty, carbonate of lime fifty-five, sulphur five, has a standard inductive capacity of 4.6. Very large variations of capacity, accompanied by high dielectric strength, are obtained by loading rubber with more or less sulphur and golden sulphurate of antimony still remaining first-class rubber. Much larger capacities, ten to twelve, are to be obtained, of course, by using very large percentages of India rubber substitutes, such as gypsum, lime, baryta, etc.; but we then arrive at inferior classes of rubber, which have not a dielectric strength to be compared with the above-mentioned combinations.

It is very easy to manufacture rubber cables with layers disposed in the order of decreased specific capacity, from the centre to the circumference. These cables

will afford a more uniform gradient to an alternating current, and hence more safety, with equal thickness. By using paper on the rubber, as above explained, we concentrate the more costly rubber insulation in the inmost part of the cable, where its higher specific strength is actually utilized.

A sample of a single-core cable made by this method for fifty-kilovolt effective tension, between the copper and the outer sheathing, has the following specifications: conductor, nineteen-wire strand, each wire 3.3 millimetres diameter; section of copper 162 square millimetres. The strand is put in a lead tube having eighteen millimetres outer diameter. It is insulated with a first layer of rubber, 2.5 millimetres thick, having a specific inductive capacity of 6.1; then with a second and a third layer of rubber of respectively 2.3 and 4.5 millimetres thick and 4.7 to 4.2 standard inductive capacity. On the rubber there is a layer of impregnated paper 5.2 millimetres thick, having a standard inductive capacity of four. The cable is then lead-covered. The total thickness of insulation is 14.5 millimetres.

At 50,000 volts, the maximum strain in the first layer of rubber is 4,400 volts per millimetre; in the second layer it is 4,450 volts, in the third 4,150 and in the paper 3,250 volts per millimetre. With a homogeneous dielectric, the maximum strain would be 5,800 volts. This cable was tested for one hour at each of the following voltages: 35,000 effective volts, 40,000, 45,000, 50,000, 55,000, 60,000, 65,000, 70,000, 75,000, 80,000, 85,000, 90,000, 95,000 and four hours at 100,000 volts without perforation. After the 80,000 volts test, its temperature was a few degrees higher than that of the room; and after four hours at 100,000 volts, twenty degrees centigrade higher.

The distribution of the potential in such a cable is easily calculated. Suppose between the conductor A (Fig. 2) and the lead B, a number n of cylindrical rings possessing respectively a dielectric constant ϵ_h where h varies from 1 to n; the ring ϵ_h is limited by the radius r_{h-1} and r_h; let V be the total voltage. The potential at a point P at a distance ρ_h in the compartment ϵ_h is given by:

$$v = \frac{V\left(\frac{1}{\epsilon_h}\log\frac{r_h}{\rho} + \frac{1}{\epsilon_{h+1}}\log\frac{r_{h+1}}{r_h} + \ldots\ldots + \frac{1}{\epsilon_n}\log\frac{r_n}{r_{n-1}}\right)}{\frac{1}{\epsilon_1}\log\frac{r_1}{r_o} + \frac{1}{\epsilon_2}\log\frac{r_2}{r_1} + \ldots\ldots + \frac{1}{\epsilon_n}\log\frac{r_n}{r_{n-1}}} \qquad (7)$$

which, for a single homogeneous insulation becomes $v = V\dfrac{\log\frac{R}{\rho}}{\log\frac{R}{r^o}}$, as before.

The above considerations have a somewhat too theoretical appearance, and it is convenient to have them submitted to the test of experiment. As for the distribution of potential along a radius of insulation, there can be no doubt; and experiment confirms it perfectly. Experiment confirms also the distribution in an heterogeneous dielectric, taking into account the various specific inductive capacities of the layers. But experiment gives some unexpected results when we consider the perforation of the cable. The system I follow is to attach the cable to a large transformer, the potential of which is gradually raised until the cable is perforated; but any potential is applied to the cable for one hour or more, before raising it. It is then also possible to note

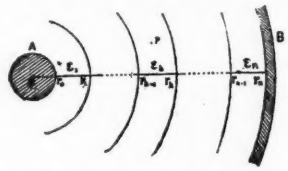


FIG. 2.—DISTRIBUTION OF POTENTIAL.

the heating of the cable for hysteresis or conductivity. The short piece perforated is then cut off, and a test is applied to the remainder, raising the potential until a new perforation, and so on. The first thing to be noted is that results are not uniform. A length of cable begins, for example, to be perforated at 10,000 volts, but the following perforations require twelve to fifteen and more kilovolts. That means that our dielectrics are not homogeneous, while perfect homogeneity is presupposed in our formulæ. Another experimental fact is the following: let us insulate a copper wire of one-tenth millimetre diameter with seven millimetres thickness of rubber, and, in the same manner, a strand of seventy wires, each of 0.25 millimetre with the same thickness of seven millimetres; the former will be perforated at 10,000 volts, the latter at 22,000. The latter is a thicker conductor, and our formula shows that a thicker conductor supports more stress with the same thickness of insulation. But if we calculate with our formula the maximum specific stress in contact with the conductor—that is to say, the stress which we think will cause a perforation—we find it to be 12,000 volts for the thicker conductor, and 32,000 for the thinner one. Similarly, I have insulated with the same thickness of fourteen millimetres of paper, a conductor of one millimetre and another of twenty-nine millimetres; the former, after one hour at 30,000 volts, was very hot and burnt at 40,000; the latter, after one hour at 50,000 volts, was still cold and burnt at seventy-five to eighty kilovolts. The maximum specific strain calculated is 10,000 volts for the thicker, and 23,500 volts for the thinner conductor. These strains of 23,500 volts per millimetre for the paper and 32,000 volts per millimetre for the rubber, are abnormally high; and the higher specific dielectric strength (apparent or real, I do not know which) that I always observed in thin insulated wires, shows that some other phenomenon exists in the dielectric.

Our formula, perhaps, lacks recognition of the mutual action of the different dielectric layers. We imagine the dielectric divided into concentric rings, for which we calculate the strain; and if it surpasses the dielectric rigidity we have assigned to the dielectric, we say that it will be perforated. Each ring is not influenced by the others, according to this manner of viewing the phenomenon, except for the distribution of potential; afterward it is considered as neither helped by nor helping the others. That is, perhaps, too statical a conception; dynamical influences are not considered here, but perforation is dynamical. It requires a certain amount of energy, which is spent not only in the first layer we have considered, but also in the others. The layers can not then be absolutely independent. Let us take, for example, a sort of concentric cable, the inner conductor made with a copper wire four millimetres thick, insulated with jute to eight millimetres; on the jute, a thin brass tape represents the outer conductor, insulated with a layer of three millimetres vulcanized rubber; the cable is then drawn into a lead pipe. Apply an 800-volt transformer between the inner conductor and the lead, leaving the brass tape insulated. At this tension the jute is perforated, between the copper and the brass tape; the jute is thus put out of service, and the total tension is brought on the rubber, which supports it very well. If we calculate the initial distribution of the potential, we see that the strain on the jute was 3,300 volts, which is too much for this kind of insulation, which will burn. The layer of rubber can not give any help to jute in this condition, for brass tape separates it from jute.

But if we make a cable absolutely like this, but without the brass tape, the phenomena are quite different. No doubt the distribution of potential and the gradient are unchanged. Let us put in circuit an electrodynamometer to measure the capacity current, and we shall have the following readings at the respective tensions:

Volts.....	5,000	7,000	9,000	11,000	13,000	15,000
Deflection..	33	62	105	150	220	297

The deflections are in the ratio of the squares of the tensions, whence we deduce that the capacity of the cable remained unaltered, under current after many hours

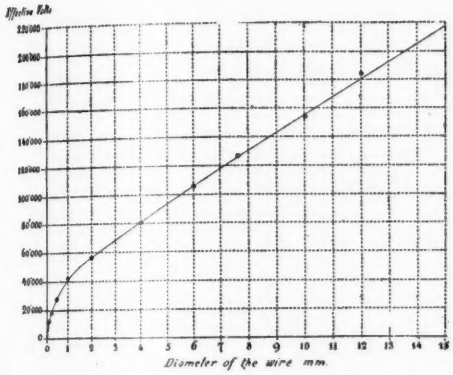


FIG. 3.—BRUSH DISCHARGE VOLTAGE FOR VARYING DIAMETERS.

testing, at potentials much higher than before. If the jute was perforated, burnt, or carbonized, the capacity ought to have increased, and the deflections would have increased more than according to a simple square law.

This mutual aid explains why it is possible to mix together very different materials and get good dielectrics. For example, there are the various mixtures of rubber, or the micanite insulations, where many layers of different capacity and strength, such as paper, mica, shellac are wrapped alternately. But if we exaggerate, we shall end by burning the weakest dielectric layers without perforating all the cable, which still continues to work.

Such a phenomenon occurs in dielectrics, especially when of organic matters, which are never homogeneous. By testing them at too high tensions, as required by some engineers, we may destroy the more strained and weaker particles of the dielectric, without immediately perceiving it. We have thus an idea of the reason for opposing too severe voltage testings which may produce deterioration in the dielectric.

If we calculate with our formulæ the thickness required to insulate for 50,000 volts, a wire of 0.1 millimetre diameter, assuming we allow the dielectric to work at 4,000 volts per millimetre, we find a number which can be expressed in millions of kilometres better than in millimetres. Such a bare wire suspended by insulators in air can effectively transport energy at 50,000 volts although air has, of course, much less dielectric strength than rubber. But if we observe the wire in the darkness, we remark that it becomes illuminated. It is surrounded by a very vivid brush discharge, and the wire has the appearance of a uniform cylinder of light of great diameter. We can consider that air has become a conductor, as regards the distribution of the potential, to the limit of the brush discharge, and we have no longer a conductor of 0.1 millimetre diameter of the brush discharge. Even if we suppose this latter to be only five to six millimetres, the millions of kilometres are reduced to two metres. That is, a wire of 0.1 millimetre suspended in the air, two metres from the earth, will be the seat of a brush discharge having an apparent diameter of five to six millimetres when brought to 50,000 volts, if we suppose air has a dielectric strength of 4,000 volts per millimetre.

Such a phenomenon can, perhaps, occur in solid dielectrics, when the conductor is very thin; perhaps the very first layers of insulation become conductors as regards the distribution of the potential. This may explain the higher dielectric strain supported by very thin insulated wires to which I referred above. This fact can, perhaps, be explained also by a deficiency of adherence between the dielectric and such a thin conductor; or, perhaps, by some particular phenomenon

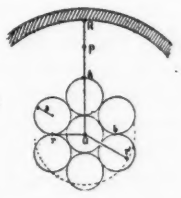


FIG. 4.—MATHEMATICAL ANALYSIS OF INSULATED CABLE TESTS.

on the surface of separation between conductor and dielectric, of which we have many examples in other branches of physics.

The influence of the diameter of the conductor on the total strength of a cable can be very well placed in evidence by taking air as an insulator. If we have an aerial line on insulators, one and one-half metres from the earth, with wires of different diameters, say from 0.12 to 15 millimetres, and attach this line to one pole of a transformer, the other pole of which is attached to an insulated distant line, we remark that at a total tension on the transformer of 12,000 volts, only the 0.12-millimetre wire commences to show brush discharges, and that this phenomenon appears only at 185,000 volts with a twelve-millimetre wire, while at 196,000 volts the fifteen millimetre wire does not yet show brush discharges. (Fig. 3.) Under tension, all the wires examined in the darkness appear to have about the same diameter, which is one that reduces the gradient below the dielectric strength of the air.

Air is a good dielectric for such researches, for we can see what happens in the dielectric. Thus, if we submit a solid wire and stranded or braided wire having all the same external size, to a very high potential, we do not see any great difference in the potential at which brush discharge commences. We can then foretell that the dielectric strength of a cable is not influenced very much by the shape of the conductor, if stranded or solid wire, at equal diameter. But it is a difficult matter to judge the phenomenon exactly by sight. I tried to take photographs at two metres distance with a lens of one metre focal distance; but photographs do not represent the phenomenon as we see it.

From another point of view, testing an insulated cable can not give us a numerical value of the difference between a solid wire and a stranded conductor, because of the irregularities and heterogeniety of the dielectric. It would, therefore, be very useful to investigate the matter by mathematical analysis. In this very difficult problem I happily was able to interest Professor Levi-Civita. It is not possible to examine here this complex theoretical study and I shall limit myself to a few words. Let us consider a stranded conductor, and let m be the number of the wires in the external layer of the strand, and R the radius of the insulation. Let r be the radius from the centre of the strand to the points of contact of a wire of the external layer, with its neighbors (knot point of the external wire layer). (Fig. 4.)

In a solid conductor of radius r insulated to a radius R, we have seen (formula 3) that the maximum gradient for a potential equal to unity is

$$G_1 = \frac{1}{r \log_e \frac{R}{r}}.$$

In the strand with m wires in the external layer, we shall have

$$G = G_1 \frac{\epsilon^{-\mu}}{1 - \mu\, r\, G_1}$$

$$F^2\left(\frac{1}{2}, \frac{1}{2}, 1 + \frac{1}{m}, \frac{1}{2}\right) \qquad (10)$$

where $\mu = \frac{4}{m} \log_\epsilon 2 + 4 \lesssim \sum_{1}^{\infty v} \frac{s}{2v+1} \frac{2^{2v} - 1}{m^{2v+1}}$ (11)

and $s_3 = 1.2020$ $s_5 = 1.0369$, etc.

are the sums of the inverse of the third, fifth, etc., powers of integer numbers; and F is the symbol of the hypergeometrical series of Gauss.

These formulas allow one to calculate the gradient, but it is well to compare the gradient of a strand to that of a solid wire of the same section. Practically the total number of the wires in a regular strand, having m wires in the external layer, is given by

$$N = 1 + \frac{m\,(m+6)}{12}$$

and the radius of a single wire is $a = r \tan \frac{\pi}{m}$, all the wires of the strand having the same radius a.

Let r' be the radius of a solid wire having the same section as the strand: then

$$r' = r\sqrt{N} \tan \frac{\pi}{m} = r\,\epsilon^{e}.$$

Putting $\epsilon^e = \sqrt{N} \tan \frac{\pi}{m}$ the formula (10) becomes (taking decimal logarithms)

$$G = G'\epsilon^{-(\mu - e)} \frac{\log_{10} \frac{R}{r'}}{\log_{10} \frac{R}{r'} - (\mu - e) \times 0.434}$$

$$F^2\left(\frac{1}{2}, \frac{1}{2}, 1 + \frac{1}{m}, \frac{1}{2}\right) \qquad (12)$$

where $G' = \frac{0.434}{r' \log_{10} \frac{R}{r'}}$ represents the maximum stress in a solid wire cable having the same R and the same section (for a potential equal to unity.)

With a stranded conductor, the condition of maximum safety for a given R is

$$r = \frac{R}{\epsilon \times 2^{\frac{4}{m}}} \qquad (13)$$

or putting the radius r_1 in evidence as before

$$r' = \frac{R}{\epsilon^1 + \mu - e} \qquad (14)$$

If we keep R and m constant and we vary a, the thickness of the elementary wire, the value of G given by the formula (12) increases when $r^1 > \frac{R}{\epsilon^1 + \mu - e}$ and diminishes in the contrary case.

If we keep constant the diameter of the insulation and the section of the conductor, the maximum strain, G, increases with m; but the term $F^2 \epsilon^{-}(\mu - e)$ has for $m = 6$ the value 1.232, and for $m = \infty$ the value 1.258. They do not differ very much, and, for safety, we can assume $F^2 \epsilon^{-}(\mu - e) = 1.26$. The value of 0.434 $(\mu - e)$ varies from 0.026 for $m = 6$, to 0.042 for $m = \infty$ and we can, for safety, assume it to be constant and = 0.042. Then formula (12) becomes:

$$G = 1.26\, G \frac{\log_{10} \frac{R}{r'}}{\log_{10} \frac{R}{r'} - 0.042} \qquad (15)$$

The discussion of the formulas brings us to the conclusion that the ratio $\frac{G}{G'}$ —that is, the augmentation of the maximum stress in a stranded conductor with respect to a solid wire of the same section —varies between the limits 1.232 and 1.462. The former corresponds to $m = 6$ with a very large thickness of dielectric; the latter corresponds to $m = \infty$ and $\frac{R}{r} = 2$—that is, to a thickness of dielectric very small in practice. In the most favorable case, the ratio being 1.232, it is advisable not to use stranded conductors for very high-tension cables, or to cover the strand with a lead sheathing.

We may observe that for $m = \infty$, the gradient tends toward its highest value—higher than with a solid wire inscribed or circumscribed with respect to m. This is not so strange, for the value of G affects only the small layer near the conductor, and however great m may be, we shall always have an external layer of small circles, having G = O at the knot-points b of the external wires, and G a maximum at the loop points A. (Fig. 4.) This is true from a mathematical point of view; but, physically, we have some compensation between the maximum and the minimum, which will bring the value of the coefficient to unity; that is, physically, we shall have for a very great m the same value as with a solid wire[1].

Experience confirms these deductions. I took a cable whose conductor was partially a solid wire seven millimetres in diameter; partially with strands of 7 × 2.34 millimetres, and 19 × 1.4 millimetres; and partially a solid wire of six millimetres surrounded by forty thin wires of 0.5 millimetre diameter. They were all insulated with five millimetres thickness of jute. If we calculate the maximum strain per millimetre by our formulas, we find that it is 0.32 of the total tension in the solid wire, 0.418 in the seven-wire strand, 0.424 in the nineteen-wire strand, and 0.432 in the strand having an external layer of forty thin wires.

During the tests the nineteen-wire strand began to burn at 17,000 volts, and was perforated at eighteen to twenty-one to twenty-three to twenty-five kilovolts; the seven-strand wire was first perforated at 19,000 volts, and successively at twenty to twenty-two to twenty-four to twenty-five kilovolts; the strand of forty thin wires began to be perforated at twenty-nine kilovolts, and afterward it experienced many other punctures from 29,000 to 33,000 volts. The first puncture in the solid wire was at 28,000 volts, probably a weak point, for the successive punctures were from thirty-two to thirty-eight kilovolts.

It is evident that the heterogeneity of the dielectric does not allow us to deduce any numerical law from these tests, but the general conclusion is that the solid wire is the strongest, and the seven-wire strand is very little stronger than the nineteen-wire strand. That is in accordance with theory, but the strand of forty thin wires ought to be the weakest of all, according to pure theory; whereas it is less strong than solid wire, but stronger than the other strands. But as I remarked

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[1] From Professor Levi-Civita's formulas we can compare the capacity of a solid wire r_1 insulated to R with the capacity of a stranded conductor of equal section, insulated to R. r being, as usual, the radius of the knot-points of the strand, the capacity of the strand is

$$C_m = \frac{x}{2} \frac{1}{\log_\epsilon \frac{R}{r} - \mu} \qquad (16)$$

where x is the specific inductive capacity. This formula is true also for an irregular strand; for example, a thick copper wire, surrounded by a number m of smaller wires, as used in some submarine cables.

Introducing the conception of the solid wire of equal section we have, taking decimal logarithms:

$$C_m = \frac{x}{2} \frac{0.434}{\log_{10} \frac{R}{r_1} - 0.434\,(\mu - e)} \qquad (17);$$

while for the solid wire cable we have:

$$C = \frac{x}{2} \frac{0.434}{\log_{10} \frac{R}{r_1}}.$$

As $\mu - e$ is always positive and increases with m, we conclude that $C_m > C$ and increases with m. At the limit, for $m = \infty$

$$C_\infty = \frac{x}{2} \frac{0.434}{\log_{10} \frac{R}{r_1} - 0.042} = \frac{x}{2} \frac{0.434}{\log_{10} \frac{R}{r_1}}.$$

Generally, the thickness of the insulation is greater than the radius of the conductor and therefore $\log_{10} \frac{R}{r}$ is generally $> \log_{10} 2 = 0.301$; therefore the increase of the capacity attains practically only a very small percentage.

above, theory points to a maximum strain for $m = \infty$, while $m = \infty$ is physically equal to a solid wire; and we must admit that, in the case of $m = 40$, the physical average which we alluded to commences to have a great influence on the result.

Of course theory can not foretell such complex phenomena. First of all, theory considers dielectrics perfectly homogeneous; and, secondly, it can not take into account the mutual aid of the neighboring layers, or molecules, which tends to equalize the gradient in any elementary zone. We must then be very careful in applying the results of theory. Theory must be for us like a lighthouse for sailors; we can use it to direct our course, but we do not depend upon it indefinitely to save us from wreck. For example, we found that

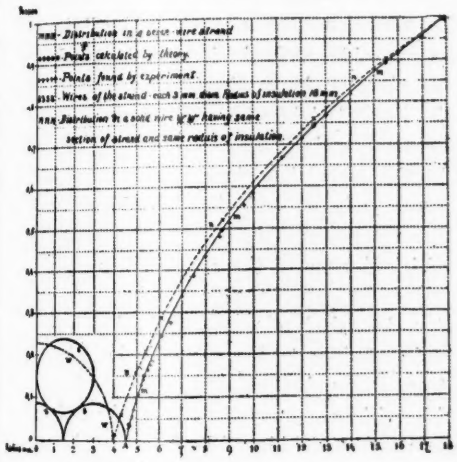


FIG. 5.—POTENTIALS AT SUCCESSIVE RADII.

with a given R, the maximum safety is obtained by taking $r = \frac{R}{\epsilon}$. High-tension cables have generally r smaller than the above ratio. After having calculated R, we might be tempted to augment r till that ratio was reached, as well as in the case where this thicker r is useless to carry the current; or we could imagine making the conductor of aluminum, thicker and more economical. But we should not forget that the heterogeneity of dielectric would cause this to be dangerous; with an impurity present we have a smaller range of thickness to rely upon, and the cable would then break down. We can, of course, augment r a little, but less than theory indicates. I have followed this practice for some time with very high-tension cables; the wire strand is covered with a lead tube, which augments its diameter. The lead has also the advantage of rendering the conductor round, and of preserving rubber from contact with copper in rubber cables, or in cables whose insulation is composed of rubber and paper, as I have explained above.

It is said that a manufacturer has found it advantageous to surround the stranded conductor with a layer of thin wires (say, 1.4 millimetres in diameter), separately wrapped with a small thickness of paper; these wires are connected with the strand, so that no difference of potential exists between the strand and the wires. It is said that a gain of twenty to twenty-five per cent was thus found in the dielectric strength of the cable. I have not a large experience with such a type of cable, but some experiments I have made do not point to an advantage, and it would be difficult to explain why there should be an advantage with this type; the small wires of the external layer become separated one from the other, so that equipotential lines must bend very much. If the advantage really exists, perhaps it is to be attributed to the larger specific dielectric strength of thin insulated wires, to which I referred above, but in this case, would it not be better to use an external layer of thinner wires, laid on contiguously, without any special insulation on each wire? Some experiments which I have made seem to point that way.

We can also test the theory by calculating the value of potential along a radius, and checking it experimentally in a sample cable obtained by soldering a strand conductor and a ring upon a thin metallic sheet, and letting a current flow in the sheet from the strand to the ring. Potentials can thus be easily measured. Fig. 5 shows the theoretical curve and the experimental one, which are very much alike.[1]

The above considerations allow us to calculate single-core cables. Three-phase cables can be calculated by considering one conductor at a potential, of say, $\frac{V}{\sqrt{3}}$ volts; we get then the radius of the insulation around each conductor. We can consider afterward the same conductor to be insulated for V volts; we get then the distance between the centre of this conductor and the lead, and, therefore, the thickness of the extra insulator around the strand of the three insulated cores. The factor of safety for this extra insulation need not absolutely be the same as for the former, as it corresponds to an abnormal case of a phase breakdown. Compound cables, with rubber, paper and jute, are calculated according to the respective dielectric strengths of these materials, distributed in the depth of the dielectric, according to the radial gradient.

Gutta-percha possesses also very great dielectric strength, comparable to that of good rubber, fifteen to twenty kilovolts per millimetre. It is not used for insulating cables for lighting or power purposes, because of its very high price, and also its especially low melting point. Such cables can easily reach a temperature which softens gutta-percha. A possible application of gutta-percha is for cables crossing lakes, rivers, and, generally speaking, for laying in cold water. It is then advisable to make a first layer of rubber insulation, on which gutta-percha is laid so that the latter, being in contact with external cold water, can not heat very much. Many manufacturers do not trust the impermeability of rubber cables, and this external coat of gutta-percha, absolutely waterproof, adds its own dielectric strength to that of rubber and obviates the inconvenience of having a heavy lead pipe, as employed by the manufacturers to which I have alluded. It is often advisable in such cables to avoid splices, and for the sake of facility of transport and laying, they can be single-cored, rather than three-cored. I may add

[1] This theoretical curve $\rho = f(v)$ is obtained from the following formulas where v is the potential, whose value is zero in the inner conductor and 1 in the lead sheathing. r, R, μ, F, have the meanings I have already explained: It is to be remembered that F $(\alpha, \beta, \gamma, x)$ is the symbol of the hypergeometrical series of Gauss.

$$1 + \frac{\alpha}{1}\frac{\beta}{\gamma}x + \frac{\alpha(\alpha+1)}{1.2}\frac{\beta(\beta+1)}{\gamma(\gamma+1)}x^2 + \frac{\alpha(\alpha+1)(\alpha+2)}{1.2.3}\frac{\beta(\beta+1)(\beta+2)}{\gamma(\gamma+1)(\gamma+2)}x^3 +$$

ρ is the radius of the point P taken along a radius O A passing to a loop point A; (Fig. 4) the potential at P has the value v.

Putting $s_1 = \epsilon^m \mu \left(\frac{r}{R}\right)^m$ $s = \frac{s_1 v}{1 - s_1 v}$, we have:

$$\rho = r\left(\frac{R}{r}\right)^{\frac{v}{\epsilon}\mu(1-v)} \frac{F\left(\frac{1}{2}, \frac{1}{2}, 1 - \frac{1}{m}, s\right)}{F\left(\frac{1}{2}, \frac{1}{2}, 1 + \frac{1}{m}, s\right)},$$

The experimental curve was obtained in a cable made to a scale $\frac{10}{1}$; the conductor is a 7-wire strand, each of 3 mm. diameter (30 mm. in the cable) insulated to a radius R = 18 mm. (180 mm. in the cable).

Values of	In a Strand of			
	7 wires, $m = 6$.	19 wires, $m = 12$.	37 wires, $m = 18$.	$m = \infty$.
$F^2\left(\frac{1}{2}, \frac{1}{2}, 1 + \frac{1}{m}, \frac{1}{2}\right)$	1.31	1.34	1.35	1.39
μ	0.484	0.282	0.157	0
$\epsilon^{-\mu}$	0.615	0.794	0.854	1
$\epsilon^{-\mu} \cdot F^2$	0.826	1.05	1.152	1.39
$r = \alpha\epsilon$	1.732	3.732	5.67	....
$0.434\,(\mu - e)$	0.026	0.084	0.096	0.042
$\epsilon^{\mu - e}$	1.062	1.081	1.087	1.107

that single-core cables for very high tensions, requiring generally a low current strength, can often be armored with steel wires; the steel wires can be separately wrapped with tarred manila, in order to lessen the section of the metal and increase the magnetic and electric resistance of the cross-circuit. For example, a 2.5-millimetre steel wire wrapped to five or six millimetres with manila, may be used without any great inconvenience from hysteresis or self-induction; the drop of pressure by self-induction can have in such cables no more importance than the drop by ohmic resistance.

I would like to add something on the properties of various insulating materials, but I fear I have already passed the limit set for papers. I shall, therefore, only say that these materials are influenced by Rœntgen rays, which lessen their specific insulation and perhaps also their dielectric strength. But cables are not made to be submitted to such rays, although they often experience brush discharges and some other emanations, which may have similar influences. I should like to add that temperature lessens the resistance of the insulation very quickly, as expressed in megohms. A paper cable at thirty-five degrees centigrade shows but one-thirtieth of the megohms it has at fifteen degrees centigrade. But temperature has very little influence upon strength to resist breakdown. Palm oil melted at fifty degrees centigrade gives a strength corresponding to that of the best oils for transformers at ordinary temperature. I have drawn experimental curves of dielectric strength of melted paraffin at fifty-five degrees centigrade and at eighty-five degrees centigrade from ten up to 160 kilovolts; they are very similar. This allows us to conclude that in this respect cables can not differ very much. I have tested two reels of paper cables, each cut in five pieces, immersed in baths at zero degrees, fifteen degrees, thirty-five degrees, seventy degrees and 100 degrees centigrade. The dielectric strength did not lessen by raising temperature, perhaps at zero degrees it was less than at seventy degrees. I noted in some oils something similar, but dielectric strength is too complex a phenomenon to be discussed on small experimental differences. Of course, that can not justify us in working at high tensions with cables too highly heated, for it is probable that heat would facilitate a chemical decay of the dielectric; but a momentary elevation of temperature is not so much to be feared as one would think at first sight.

In conclusion I may say that the above considerations can be applied to some other matters. They explain, for example, the brush discharges between the petticoats of insulators. An insulator with many petticoats can be considered like a system of condensers in series; a large part of the tension is taken by air, which has three to four times less specific inductive capacity. They explain the "digestion" of the wooden pins with iron cores, in the insulators; for the gradient is greatest in the pins, and they become carbonized with age. They explain also the phenomenon that insulators tested with pins stand less than when tested with water, for water offers a larger and smoother surface. They explain the brush discharge at the surface of an insulated wire, drawn into a metallic pipe (for example, in crossing a wall), for we have added in this case an external layer of air to the solid insulation; but air has a low standard inductive capacity, and, therefore, it absorbs much tension, with a too large gradient. In a similar manner we can explain the brush discharges at alternators, during very high-tension tests. These considerations explain also why the alternator coils separately wound, and wrapped with alternate layers of tapes and varnishes, are generally perforated in a corner of the coil, or corresponding to an external corner of the conductor, for there is here a higher gradient. They can suggest some improvements in the construction of insulated coils for alternators, for example, by increasing the radius of curvature of the bunch of conductors, or by employing in the intermost part of the insulation some material like mica, which has the highest capacity, together with the highest dielectric strength against puncture. In short, they explain many facts which have been observed in practice.

N-Rays at the British Association.

At one of the meetings of the physical and chemical sections of the British Association for the Advancement of Science, held recently, a discussion on N-rays took place which is reported in the current issue of *Engineering*. This can hardly be called a discussion, since but one side of the matter was presented. The principal speaker was Dr. Lummer, of the Physikalischer Technischer Reichsanstalt. Dr. Lummer has tried in vain to obtain the results described by Blondlot and others, and he believes that if it had not been for the notice which the French Academy of Sciences had taken of the mysterious rays, it would not have been worth while to discuss the question. It was thought first that the effects might be simply physiological, but photographic results have been claimed. The main evidence rests on increased luminosity of fluorescent screens. He had quantitatively examined what increase in luminosity could really be distinguished, and had found that an increase of less than thirty to forty per cent could be seen; but the N-ray advocates rely upon much smaller effects. As our fovea, on which we rely in direct vision, contains only cones and no rods, while the rest of the retina is set with cones and rods, images appear unsteady and variable just when we try to fix our eye upon them. Looking straight ahead in the dark, but fixing the attention upon a candle held a little to one side, and slowly moved toward the observer in a direction parallel to the line of sight, the pupil opens more and more, and the image becomes brighter. At the same time, however, the ciliary muscle relaxes, and the light intensity therefore seems to fluctuate. Dr. Lummer criticised some of the arrangements suggested for experiments, and, in conclusion, he asked all present who had experimented upon N-rays to signify this. A good number responded. Following this with a request for those who had been successful in observing the phenomena, no response was received.

Mr. Butler-Burke thought that Blondlot's photographic effects were due to the influence of the screens employed in increasing the capacity of the apparatus, and thereby diminishing the spark brightness. He, himself, had examined many people, but had, in no case, obtained any effect upon the sight. Referring to Blondlot's determinations of the wavelength of the N-rays, he said that no defraction fringes could have been seen, as the energy of the light had been reduced to one-eight-thousandth. Under these circumstances, the determination of the velocity of the Rœntgen rays and of their polarization will have to be reconsidered.

Unfortunately, no one was present who had been successful in observing the Blondlot effects, and hence the other side of the question was not presented.

The Italian government has received permission from China to establish wireless telegraph stations in Chinese territory.

ELECTRICITY FROM WATER POWER.[1]

BY A. A. CAMPBELL SWINTON.

It should be gratifying to our national pride to know that probably the very earliest example of the production of electricity by means of water power on a practical scale and its transmission to a distance was the installation put up—for the purpose of lighting—at Cragside, Northumberland, by the late Lord Armstrong in the year 1882. This plant, which was still in daily use in the year 1884 when the author saw it in operation, consisted of a Siemens continuous-current dynamo which was driven by means of a belt off an eight-horse-power water turbine operating with a fall of thirty feet, the electricity—which was delivered at ninety volts pressure—being carried by bare overhead wires attached to porcelain insulators on poles to the house about a mile distant. It is an interesting fact that when the installation was first put to work it was designed to operate with only a single wire, connection being made to the hydraulic power pipes at the one end and to the ordinary household water pipes at the other, the earth being expected to form a sufficient return in the manner employed in telegraphy. This plan, which was adopted on the advice of the late Sir William Siemens, was found to be quite ineffective, as, owing to the low voltage employed and the exceedingly rocky nature of the ground, no useful amount of electricity could be transmitted, until the earth return was done away with and a second metallic conductor substituted.

Though this twenty-two-year-old English example of electricity developed by water power and transmitted to a distance was, as already mentioned, probably the first such installation in existence in the world, the great development of such installations has, up to recently, taken place almost exclusively abroad. No doubt up and down this country a very considerable number of small electric plants operated by water power has been put up for private house lighting and such like purposes, and there are even towns, such as, for instance, Salisbury and Keswick, where water power has for long been employed to assist steam power for electrical production for public and private lighting, the water power being in these instances found of great value for the purpose, more especially of maintaining the supply during the periods of minimum load. A few hundred horse-power will, however, probably cover the whole of the plants of this character at present running in Great Britain, which is an altogether insignificant amount compared with the much larger corresponding figures for the continent of Europe, America and other countries.

To obtain accurate statistics as to the amount of water-horse-power at present employed for electrical production throughout the whole world is a very difficult matter, as in many countries no figures are available, while in others, such as are obtainable are not up to date. The following summary, giving an aggregate horse-power of nearly one and one-half millions, comprises all the hydraulic electricity works of which the author has been able to obtain particulars. He has, however, no doubt that there must be many others in existence to which he has not been able to find any reference, while again, in the case of a number of the installations which have been included, the horse-power now employed is greater than that in use at the time that the statistics were made out.

Water-Power Electricity Installations —United States of America, 527,467 horse-power; Canada, 228,225 horse-power; Mexico, 18,470 horse-power; Venezuela, 1,200 horse-power; Brazil, 800 horse-power; Japan, 3,450 horse-power; Switzerland, 133,302 horse-power; France, 161,343 horse-power; Germany, 81,077 horse-power; Austria, 16,000 horse-power; Sweden, 71,000 horse-power; Russia, 10,000 horse-power; Italy, 210,000 horse-power; India, 7,050 horse-power; South Africa, 2,100 horse-power; Great Britain, 11,906 horse-power; total, 1,483,390 horse-power.

It, therefore, seems reasonable to suppose that the total amount of water power actually used for electrical production throughout the world at the present time must exceed 2,000,000 horse-power, which is about double the total steam power at present devoted in Great Britain and Ireland to the same purpose.

It is interesting to calculate what would be the amount of coal required to produce this large amount of horse-power were it generated by steam engines in the ordinary way; in other words, what is the saving of coal that the adoption of this amount of hydraulic power entails. Many of the hydraulic plants, particularly those which are used for chemical processes, operate at full power continuously night and day, but others work for shorter hours. Assuming, however, that the whole 2,000,000 horse-power is in use for twelve hours per diem, in other words, is employed on the average with what engineers call a fifty per cent load-factor, and assuming, as is reasonable, that were the energy produced by means of coal at least three pounds of this fuel would be required on the average per horse-power hour, we get 5.86 tons of coal per horse-power-year, or 11,720,000 tons of coal saved annually on account of the 2,000,000 water-horse-power utilized. Though this may appear a large figure, it amounts to less than two per cent on the total output of coal in the world, which, on the average of the last five years, was 632,000,000 tons per annum. Assuming, however, an average cost of coal of ten shillings per ton, this 11,720,000 tons represent £5,860,000 yearly, an amount which it would take over £100,000,000 of capital earning five per cent per annum to provide.

Apart from mere magnitude, many of the more recent examples of hydro-electric engineering abroad, especially in America, are interesting by reason of the enormous distances over which the electric energy is being economically transmitted and the very high electric pressures that in numerous cases are being successfully employed. The longest distance over which transmission has so far been commercially effected is probably the 232 miles of line belonging to the California Gas and Electric Corporation, which stretches from the De Sabla power-house *via* Cordelia to the town of Sausalito, which is situated on the opposite side of the Golden Gate straits from the city of San Francisco. What this transmission means will be realized when it is stated that the distance covered is about equal to that which separates Cambridge from Newcastle-on-Tyne. The same Californian company also owns the Colegate and Oakland transmission line, which runs 142 miles from the Colegate power-house, where 14,000 horse-power is developed from a head of water of 702 feet.

Another very long line is that which reaches from the Electra power-house *via* Stockton and Mission San Jose to San Francisco, a distance of 147 miles, over which 10,000 horse-power is being delivered regularly. This line belongs to the Standard Electric Company, which has 217 miles of power line with a capacity of 27,000 horse-power in operation. The voltages employed, as is to be expected having regard to the distance covered, are very high, ranging from 55,000 to 67,000 volts, 60,000 volts being apparently the standard figure for many recent installations, of

[1] Paper read before section G of the British Association, Cambridge meeting.

which the following table gives some examples.

PLANTS RECENTLY INSTALLED BY THE STANLEY ELECTRIC MANUFACTURING COMPANY, PITTSFIELD, MASS.[1]

Name.	H. P. Capacity.	Voltage.	Transmission Distance. Miles.	Head of Water. Feet.
Quanajuato Power and Electric Co., Mex....	8,000	60,000	101	300
Washington Water Power Co., Spokane.....	12,000	60,000	110	68
Kern River Power Co., Los Angeles, Cal.....	16,000	67,500	110	....
Pierce Co.....	26,000	55,000	40	....
Mexican Light and Power Co., Mex.....	....	60,000	110	1,500
Winnipeg General Power Co	10,000	60,000	60	40
Canadian Niagara Power Co.....	....	60,000	93	....
Electrical Development Co. of Ontario.	....	60,000	93	....

Mention should also be made of the 50,000-horse-power and the 125,000-horse-power plants for the Canadian Niagara Power Company and the Electrical Power Company, of Ontario, contracted for by the Canadian General Electric Company, both of which will employ pressures ranging up to 60,000 volts, while, to pass to another quarter of the globe, the Cauvery falls electric power scheme in India has now been at work for over two years, and transmits 5,000 horse-power to the Mysore gold mines, a distance of ninety-two miles, using a pressure of 35,000 volts.

Turning now to the British Isles, the only large scale plant for the production of electricity by water power at present in operation in this country is the well-known installation of the British Aluminium Company at Foyers. This installation, which was originally designed by the late Mr. Birch and carried out by Mr. W. Vaux-Graham, has been at work ever since the year 1896, and the whole of the power has been employed for electric-chemical purposes on the spot. A small percentage of the power is utilized for the production of calcium carbide, but the bulk is, and in the near future the whole of the power will be, used for making aluminum. At present the gross horse-power of the plant is 7,000 horse-power, but plant for a further 2,000 horse-power is at the present moment being installed, and will shortly be working.

The water is derived from the River Foyers, which has a catchment area of upward of 100 square miles. Storage is effected by means of two lakes which have been joined together by the raising of dams and embankments, the result being a continuous lake of about five and one-half miles long by about half a mile wide. The storage thus obtained is sufficient to run the entire plant continuously day and night for about fifty days. From the River Foyers the water is first passed through a tunnel eight and one-half feet diameter, cut through the solid rock, to the penstock chamber, from which the water is delivered by separate cast-iron pipes to the turbines, which are installed on the shore of Loch Ness, and into which the water is finally discharged, the available head of water being 350 feet.

The British Aluminium Company has obtained parliamentary powers for a further large water-power installation on Loch Leven. It is its intention to commence immediately the development of this scheme, which is capable of giving 17,000 gross horse-power. The reservoir is artificial, and will contain about 150 days' storage of the full power, the head of water at the turbine being 964 feet. It is anticipated that the whole of this power will also be taken up in the manufacture of aluminum on the spot, no distant transmission being, at present, at any rate, contemplated.

Another interesting water-power scheme of considerable dimensions is at the present moment being developed in Wales by the North Wales Electric Power Company, which has obtained parliamentary powers for this purpose. Its first installation is at present being erected under the superintendence of Messrs. Harper Brothers, the company's engineers, and derives its power from Lake Llydaw, on Snowdon. This lake, into which runs the water from Lake Glaclyn, is about one and one-fifth miles in length and about a quarter to half a mile in width. Its area is 5,500,000 square feet, and it derives its water from a catchment area of about one and three-quarters square miles, including the summit of Snowdon. Being in the track of the Atlantic depressions, this area has one of the heaviest rainfalls in Europe, amounting on the average to 180 inches per annum. In 1903 it reached the phenomenal figure of 250 inches. The prevailing winds are from the sea, and the atmospheric moisture is driven up the sloping side of the mountain, and on being condensed at the summit is discharged in the form of rain or snow on the eastern side over lakes Glaslyn and Llydaw. The fall of the year gives the wettest months, and it happens that the quantity running from the lakes in spring is averaged up by the snow melting on the sheltered eastern side.

By means of a dam about 100 feet in length, the level of the lake is to be raised twenty feet. The water will be drawn from the lake by means of a tunnel 600 feet in length at a point thirty feet below the present level, or fifty feet below the level when the dams are completed, with the result that there will be sufficient storage for meeting a ninety days' drought. The total fall utilized will be about 1,150 feet, and the total horse-power available, on the basis of a nine hours' working day, is calculated at 8,200. The first installation consists of two steel pipe lines and four 1,000-kilowatt sets, each consisting of a double tangential water-wheel coupled to a three-phase alternator giving 11,000 volts at forty periods per second. The company will develop the full horse-power of Lake Llydaw before proceeding further, but they have also acquired a further water power at Llyn Eigiau, in the Conway valley, where a fall of 800 feet is obtainable, and where it is calculated there will be nearly twice as much horse-power available as there is at Llydaw.

One of the first objects of the North Wales Electric Power Company, as soon as its installation is completed, will be to supply energy for the working of certain light railways which it controls in the district. It is, however, in addition, intended to supply electric energy throughout a large area, comprising the whole of the counties of Carnarvon, Merioneth, Angelsea and also a portion of the county of Denbigh. Three-phase currents are to be used, and the transmission lines will be of bare copper wires, 0.324 inch diameter, carried on insulators triangularly placed on wooden poles. A large proportion of the transmission lines will be carried along the track of the above mentioned light railways. Lines are to be laid to the principal slate quarry districts of Nantlle, Llanberis, Penrhyn and Festiniog, where a considerable demand for power exists. The distances from the power station to these places range from six to twelve miles.

The latest water-power electric scheme in the United Kingdom is that of the Scotch Water Power Syndicate, which has, by agreement, obtained from Lord Bredalbane and the trustees of the Colquhoun estate of Luss important water-power concessions. These agreements have been negotiated by Mr. E. Ristori, who, it may be mentioned, was one of the original founders of the falls of Foyers installation, while the engineering and electrical details have been worked out by Mr. William Vaux-Graham and the author.

The first power that it is proposed to

[1] For these particulars the author is indebted to Mr. C. C. Chesney, the chief engineer of the Stanley Electric Manufacturing Company, which has recently installed these and numerous other similar plants.

develop is one connected wth Loch Sloy, which is situated some five miles north of Tarbot on the side of Ben Vorlich, between Loch Long and Loch Lomond. Loch Sloy, which is situated some 757 feet above Loch Lomond—which, in turn, is some twenty-six feet above the sea level—is fed from a catchment area of about 3,801 acres, which includes one side of Ben Vorlich, which, with its 3,092 feet, is one of the highest mountains in Scotland. The district has the very heavy rainfall in some seventy-four inches per annum, of which it is calculated that sixty inches will be collectible.

A dam will be constructed at the eastern end of the loch, which will raise the height of the latter by some sixty feet. This will impound some 240,000,000 cubic feet of water, capable, with a calculated net fall of 700 feet to Loch Lomond, of maintaining 6,000 electric-horse-power on a twenty-five per cent load-factor for the maximum possible periods of drought, which are calculated at 100 days. From the loch the water will be taken in the first instance along an open conduit 3,650 yards in length, which will follow the contour line round Ben Vorlich till a point is reached almost immediately above the position where the power-house will be constructed, on the shore of Loch Lomond, at a spot called Inveruglas. From the end of this conduit to the power-house the water will be conveyed in steel pipes, the length of the pipe line being about 600 yards and the height of fall 700 feet.

From the power-house an overhead transmission line is to be constructed in duplicate for the purpose of conveying the electric energy to the industrial areas of the Vale of Leven and the Clyde, which comprise the towns of Dumbarton, Helensburgh, Renton, Alexandria and includes shipbuilding yards, engineering and dyeworks, calico-printing works and factories of various descriptions, many of which have already intimated their desire to be supplied. The transmission line, for which private wayleaves have been obtained throughout, will be overhead on poles, starting from the generating station at Inveruglas, and continuing across country for a distance of twenty-two miles to a substation which will be situated at Renton, about midway between Dumbarton and the foot of Loch Lomond, in the centre of the Vale of Leven industrial area. At this substation the voltage will be reduced from the 40,000 volts, which it is proposed to employ for the long overhead transmissions, to some 6,000 to 10,000 volts, it being the intention that the distribution from the substation to the various works shall be underground.

The following are the efficiencies which it is calculated will be obtained:

	Full-load Efficiency. Per Cent.
Open conduit, Pipe line, Turbines	75
Three-phase generators	94
Step-up transformers	97
High-tension transmission line	93
Step-down transformers	97
Underground distribution (say 6,000 volts average)	95

This is on the assumption of the energy being delivered to customers at 6,000 volts. If, as is probable in most instances, it will be delivered at lower voltages, there will be a further transformation, the efficiency of which will be ninety-five per cent in the case of transformation in pressure only, and eighty-six per cent in the transformation to continuous current, making total overall efficiencies of 55.6 per cent for three-phase current delivered, and 50.3 per cent for continuous current delivered.

So soon as a market has been found for the total power procurable from Loch Sloy it is intended to utilize a further water power, for which the rights have also been obtained, at Ardlui, about two miles further up Loch Lomond. This power is also fed by a small loch with an available fall of 800 feet, the horse-power obtainable being about half that available at Loch Sloy. The Scotch Water Power Syndicate has, in addition, obtained the rights to still further water powers on the Breadalbane estate that exist further north, and these will be utilized as soon as the demand for power justifies the capital expense. It is because of these additional powers (which will considerably extend the length of the transmission) that it is proposed from the start to employ so high a pressure as 40,000 volts.

It is estimated that the total cost of the Loch Sloy scheme, including the transmission line and the distribution to the various factories, will not exceed £200,000 which, on a basis of 5,000 horse-power delivered, works out to about £40 per horse-power—everything included. Seeing that many of the existing electric generating stations worked by steam have cost almost this amount for land, buildings, and generating plant, this does not appear to be an excessive figure, and it may be pointed out as an interesting fact that the twenty miles of overhead transmission line only accounts for some £24,000, or about twelve per cent of the total expenditure. This, coupled with the fact that the calculated loss on the transmission line at full load will only amount to about seven per cent, and the step-up and step-down losses to another six per cent, making thirteen per cent in all, will give some idea of the extent to which the length of the transmission line is but a comparatively unimportant factor in schemes of this description. It may be pointed out further that the above-mentioned line loss of seven per cent is upon the basis of only one of the two duplicate transmission lines being in use. When both are employed the line loss will be reduced to three and one-half per cent, and the total transmission loss at full load will be only a little over ten per cent.

The main transmission will be on the three-phase system over two sets of three copper conductors, each about three-tenths inch diameter, the possibility of conveying as much as 5,000 horse-power over a distance as great as twenty-two miles with only three and one-half per cent loss by means of such comparatively small wires being, of course, due to the high pressure employed. Indeed, using pressure as high as 40,000 volts when it is a matter of transmitting comparatively small amounts of power, as, for instance, the 600 horse-power or thereabouts that under the present scheme it is expected will be required for the supply of the town of Helensburg, the interesting point arises that the minimum size of conductor allowable is limited, not only by electrical conditions, but by considerations of mechanical strength. On the main transmission line the conductors will be at a minimum height of forty feet from the ground, while at all crossings over roads they will be enclosed in a wire cage to meet the Board of Trade requirements for ensuring public safety.

The application of water power in the United Kingdom can, of course, never attain the dimension that it has already reached in America and elsewhere; still, the above brief account of what is at present being done in Scotland and in Wales shows that there are possibilities even in this old country of which till recently but few were aware. As regards the economies of electrical generation by water power, no general rule can, of course, be enunciated, and every case must be dealt with on its merits according to local circumstances. Yet notwithstanding, it is possible to give an indication of what is generally involved, having regard more especially to the fact that, with water power as a rule, interest on capital plays a much greater

part in determining the cost than do labor or upkeep.

Avoiding, on the one hand, small powers, where the costs are likely to be abnormally high, and, on the other, very large powers, such as we do not possess in this country, it may be taken generally that interest on capital, depreciation, upkeep and working expenses in this country will amount to about twelve per cent on the capital expenditure.

On this basis it is easy to see that to be economically sound, the capital involved must not exceed eight and one-half times the annual price which can be got for the whole of the energy. For instance, if 5,000 horse-power is available for sale and £6 can be got for each horse-power on the average per annum, the capital involved must not exceed £52 per horse-power, or £260,000 in all.

To conclude, it has been said that the greatest benefactor to the human race is he who makes two blades of grass to sprout where only one grew before. On this principle the utilization of natural water power is obviously to the public advantage. When mechanical or electrical energy is generated by the burning of coal, it is a matter of the consumption not of interest but of capital. On the other hand, every water-horse-power that is put to use is something added, mundanely speaking, for all time, to the permanent resources of mankind.

Engineering and Trade Opportunities.

Vice-Consul-General Murphy writes from Frankfort, Germany, of the following trade opportunities: the department of the state railways of Roumania will award contracts for the enlargement of the electric plant at Bukharest and of tools and machinery required for electric lighting and power for the new railway workshops in that city. The department will also receive proposals for supplying machine tools required by the state railways. The German consul at Belgrade reports to his government that within the past year a considerable number of electric plants and other establishments have been built in Servia. The consul advises German manufacturers to send expert representatives to Servia to study conditions on the spot. Electric plants for lighting, supplying power, etc., are to be built in the Mexican cities of Jiminez, state of Chihuahua, and Allende, state of Coahuila. An electric power station is to be built at Santos, Brazil. The municipality of Penang, Strait Settlement, intends purchasing electric street cars. Particulars can be obtained from Preece & Cardew, 8 Queen Anne's Gate, Westminster, London.

PLANNING A TELEPHONE SYSTEM.[1]

BY SAMUEL G. McMEEN.

If all the towns were about alike in the way their people are distributed over the town's territory; if the prices of materials did not change; if no improvements were made in machinery and supplies; if there were reasonable expectation that styles and fashions in telephone things would be constant; if it were just as easy to dig holes and ditches in the ground in one town as in another; if the people in one town were just as wealthy as in any other, and if the long-distance line system were now complete enough to cover the continent; then planning a telephone system would be easy. In such ideal conditions a person with the telephone fever might place an order with the manufacturers for "one standard equipment of so many stations," and with the contractors for "one standard system of so many lines." And there would be a great final gratification in the fact that the real investment would be found very much like the original estimate; a condition which happens so seldom as to be quite striking when it does occur.

It is no news to say that a plan for a telephone system, whether it includes merely an exchange for a town, or a toll line system as well, must plan to build the system at the lowest possible cost in investment, and the lowest possible costs of operating the thing when done, keeping it in operating condition, replacing parts of it when they are worn out, and replacing other parts at just the time it is wisest to do so to get the advantages of newer and better ways. There is a real difference between the annual cost of keeping the thing in operating condition, ordinarily called "maintenance," and the annual cost of replacing parts which are no longer serviceable, due to their having worn out or become superceded by something better. It has been supposed that the cost of operation depends mostly on good management, and this is probably true; but the more recent development of automatic apparatus is causing some of the old timers in the business to sit up and take notice. I do not mean to say that it is always cheaper to make connections by machinery than by hand, but that there is much more reason now to believe that such a result may be reached than there was five years ago.

[1] A paper read at the St. Louis convention of the Independent Telephone Association of the U. S., September 22, 1904.

To accomplish the lowest cost in investment does not always mean lower annual costs in maintenance, depreciation and operation. You have seen systems which impressed you as having come into being largely by accident; in some of these a little inspection of the accounts will show such annual sums of unnecessary outlay as are really adding substantially to the effective investment. As a fundamental principle, it is supposed to be best to run your business on your own capital; but there are many telephone exchanges in which borrowed money applied in betterments would pay interest on itself, and a substantial profit besides. This because of the greater saving, even though the borrowed investment did not increase the gross revenue at all.

Differences of opinion among telephone men as to the right number of offices to establish in a fairly large city have been supposed to be due to the natural tendency of men not to agree with each other. In large cities in Europe there exists a liking for one central office, with a large number of lines. In the larger cities in the United States, it is quite usual to prefer a number of offices. The explanation is very simple. As telephone systems are now built, a very large part of the annual cost of merely owning the system a year at a time is in the wire plant; and this in a large city of only reasonable density of population varies strikingly with different arrangements of the lines in offices; when they are centered in one office it is quite the rule that the average length of line is greater than when part of the lines centres in the office and other parts in others. It is true that where there are several offices in a city, these must be joined to each other by trunk lines; but as trunk lines are so heavily used, it is never true that the total amount of wire in subscribers' lines and trunks is as great with several offices as it is with one.

In the cities of Europe a great many more people live in a given space than here. The lines are therefore shorter. Labor is cheaper. And in some cases, a one office arrangement was chosen because the engineers made a bad guess.

If there were no other reasons to be considered, more than one office in a town would generally be cheapest; but, fortunately or unfortunately, the cost for operators is always greater in the several office arrangement than in that of one office. But in any town, whatever, an arrangement can be found in which the total cost of owning and operating and

keeping up the lines and offices, when taken as a whole, will be the least. In laying out a system of reasonable size, finding the number of offices and where they ought to be is one of the important considerations; and it is a condition which, if poorly established, can absorb a surprisingly large amount of money each year.

In a small city, one office is nearly always the best arrangement, and in the past it has been customary to assume that this would be so, and to plan accordingly, leaving the consideration as to what future arrangement might be best to be taken care of by the future. It has resulted—and will result again—that it is found that the one office originally established, is in a surprisingly bad place when the day does come that others must be opened. By being in a bad place I mean simply that when additional offices are established, this first one may be found by its location to be adding to the annual cost of owning, operating and keeping up the system.

In establishing any office, even if the exchange be small, wisdom of choice is required with reference to the location of the building, its size and its character. I have pointed out that the location of the building has an effect on the length of lines. It also has an effect on the fire risk, and sometimes there is also a risk from high waters. Service has been interfered with by fire in an adjoining building, even though there was no immediate danger to the central office itself. Whether the building be owned or rented, the arrangement of the apparatus in it is best when not only the exact location of future additions is taken into account, but when a growth of unexpected amount is provided for. Instances have occurred where a plan otherwise good has been found to be very bad because the growth was great enough to carry the switchboards against a wall which could not be removed and in which direction the building could not be extended.

The best central office arrangement, other things being equal, is that which carries the entering cables, and those which are joined to them, through their runs with the greatest directness, and, therefore, at the smallest cost. In the larger offices a saving of a foot-length in a cable run is a very considerable advantage.

As to choice among the many types of equipment now available, one may gain a great deal of information from the manufacturers, as they will tell you all about the good points of their own manufacture, and sometimes about the bad points of that of others. A great deal of light is thrown upon the situation, and the embarrassment of choosing is much relieved by the application of a few simple but exacting tests to samples submitted by the manufacturers. In every case the prospective purchaser has a great advantage if he purchases in accordance with definite specifications covering his exact needs, because these things not only assist the manufacturer in knowing exactly what is called for, but assist the purchaser in protecting himself in case the things delivered are not satisfactory.

In all, except the very smallest offices, careful planning of the equipment will usually make a saving in the expense of operators. Where local and toll duties devolve on the same operator during quiet hours, economy and convenience may both be accomplished by an intelligent arrangement of the switchboard locations.

Since the first introduction of lead-covered cables, there has been a decrease in the use of bare open wire. Except as to the cost of the system, there is no reason why all wires should not be in cables. Where the development is very dense, it is really cheapest to carry cables directly into the buildings, but in residence districts it is best to strike a happy medium between all cables and all open wire; because a subscriber should be connected as soon as his contract is secured, because to do so means a line must be ready for him in advance; because the future development of the residence districts can be guessed with less exactness than the denser districts, it is necessary that the multiple tap method of distributing cable conductors be used at least in some degree. If intelligently applied, the multiple tap method also reduces the wire plant cost below that of the more cumbersome open-wire treatment of line ends, with its attendant maintenance expense and annoyance of service interruption.

Like many other good things, however, the multiple tap system may be practised to excess. There is no involved mathematical formula which will answer the multiple tap question for a given town, but it is possible, and necessary as well, to make comparisons between the costs of several arrangements for a given territory. And these comparisons should be made with care enough and patience enough to make certain that the best way has been chosen when a conclusion really is reached.

In recent times quite substantial changes have taken place in the costs of things which go to make up the wire plant. It is gratifying that this is so, because this part of the system has always been predominant in using up investment. No matter how cheap, however, the materials for line construction may become, the proportion of labor cost to the total cost of the constructed thing will remain large. As a comparison, it may be interesting to know that the equipment for central offices and subscribers may be installed for from five per cent to ten per cent of its cost, while very many of the elements of line construction cost as much for labor as for material. A thing which the constructor, therefore, must plan toward, is the elimination of labor wherever possible. There are two good results of such watchfulness; one is the natural keeping down of the total cost, and the other a higher final depreciated value. For if it costs a dollar to put a dollar's worth of copper in place, fifty per cent is more than you can ever get out of it by selling it as junk. This is one of the reasons why placing cables underground has had such an effect on annual telephone costs. Two cables just alike, one on poles and one in ducts, may reasonably be expected to have an annual depreciation cost of several to one in favor of the underground cable; and this is without taking into account the superior lasting qualities of the structure which cares for the latter.

Without citing further examples, I think I may generalize by saying that it is necessary to apply these and other simple rules to the planning of a telephone system for a town, and to lay out the course of action which, when methodically pursued, will bring the original estimate and the actual cost reasonably close together, not only as to the first investment, but to the annual charges when in service.

Not the least important thing in preparing to make such a plan is to get on the ground, and become saturated with the local facts. It is gratifying to find by experience that an outsider may get such a knowledge of a town by tramping over it, by consulting public records, and by diligent enquiry from those who know, as to enable him to compile field notes almost as accurate as to the things he needs to know as those taken by the civil engineer in laying out a railroad. By this I do not mean merely finding out what is under the pavement, and where are

alleys and where none, because these are simple matters. The important thing is to get so many facts about the town as to enable correct guesses to be made as to where the future growth of the town will occur, about how fast it will go on, and in what direction it will push; what kind of houses will be built in this quarter, and what kind in that; the probable change in the business area, and its present tendency of expansion; is the street railway system going to develop this residence area more than that, or will a new district spring up next year? One of the greatest helps toward reasonably correct conclusions in this plodding sort of investigation is to cut it up into such small pieces that the great quantity of estimates will prevent a serious error being introduced by a few bad ones. In five hundred guesses the influence of one wrong one is not only relatively small, but each guess is easier to make with truth.

In all of these cases, the elements of estimate are made with a view to determining not so much what the town is to-day, but what it will be at the end of a selected period. It is not difficult to build a system for the present for a town of known conditions. It is more difficult, and more important as well, to make the plan complete for the town which is to be, because it is that town which the system must serve. The only difference between the best method of planning to-day and those which have been used heretofore, is that the later method uses more care in details, and realizes more fully the kinds of mistakes which are likely to be made. Perhaps it reflects little credit on the engineers, but it is distinctly to the advantage of their employers that they have made almost all the blunders that are possible to be made; and it goes without saying, of course, that a man of reasonable common sense will not make the same mistake twice. If it were only long-lived enough, this tendency might result in quite a perfect telephone condition being reached.

One of our prominent western civil engineers, while visiting his uncle in New England, attempted to answer persistent questioning as to what he did for a living, by explaining the scope of his profession, how he and his brethren "harnessed the forces of nature to the benefit of man," and how through their activity, intelligence and experience, man would ultimately reach his deserved proud position in command of the universe. The blushing modesty which inspired these restricted statements suffered a rude shock upon the query of his relative: "Ain't this engineering after all a sort of fancy business?" It is somewhat with the view of letting you into our confidence that I have made the foregoing admissions, for engineering telephone properties after all is really a simple, common-sense matter, the more successful as it involves the more patience and sound judgment.

So far as I have described the manner of such planning, it has been in the way of accomplishing minimum costs. It goes without saying that the minimum cost plan must involve due consideration of the quality of service to be given. A plan which will not make good service, falls short of its mission, quite as would a manufacturing property which would not turn out good product. This brings me to the very important and widely neglected feature of planning all parts of a telephone system, whether in a town or between towns, so that it may ultimately form a part of a successful continental telephone system. I do not mean by this merely that a consolidation of telephone interests may take place. What I do mean is that any plan falls short of its mission which does not involve making all elements as nearly as may be such as will be serviceable and useful when the continent is covered with a complete network of long-distance lines, connecting exchange with exchange. You may answer that the day of such a system is so far away that it is foolish to waste money on it now. My answer is that the day in question is not so far away as many are thinking, and that it does not always mean an excess expenditure to take this into account. Further, in any telephone system which is wisely planned, there are elements which ought to last so long as to be overtaken by the time of which I speak. It is no fancy dream to expect such a condition. We will agree on this if we will stop to think of what has been accomplished by the independent interests already. I am advised that there is under consideration the construction of a considerable length of long-distance circuit of heavier copper than has ever been erected for any purpose of communication, and this by an independent company. I can call to mind exchanges lying in the region of these excellent projected circuits from the stations of which I should be surprised to receive good speech even over lines of such cost and quality.

The New Equipment of the New York Central's West Albany Shops.

The equipment of the West Albany shops of the New York Central Railroad Company is nearly complete. The apparatus was furnished and installed by the General Electric Company. A power-house of sixty by one hundred feet is located in the centre of the shop buildings. Four Franklin water-tube boilers of 500 horse-power each, operating at 175 pounds pressure, and two Bellwood cross-compound 1,000-horse-power engines are the prime movers. Two three-phase alternating-current generators of 750 kilowatts, supplying a voltage of 480, are direct-connected to the engines. Two Woodbury engines, direct-connected to a 250-volt exciter, form the exciting plant. A synchronous motor set, consisting of 100-kilowatt 480-volt synchronous motors, and a 100-kilowatt 250-volt direct-current generator set operate the cranes. These have been so arranged as to be thrown in on the exciter buses when used for exciting the main generator in case of trouble with the engine-driven exciter. For lighting, three single-phase transformers raise the voltage from 480 to 2,300 alternating current for distribution to the various lighting transformers located at suitable points about the shops. Induction motors will replace the long-driven shafts.

English Railway Statistics.

The Board of Trade, of London, has recently published its report on the British railways for 1903. A new feature of the report is the comparison of the number of passengers traveling third-class with the number carried by the tram lines in England. Beginning in 1896, the number of third-class passengers carried on the railways was 888,604,000. The number carried by the tramways was 759,466,000. There was a steady increase in the latter until 1900, when the number carried by the trams exceeded the third-class passengers by over 25,000,000. The figures for 1903 were, third-class, 1,086,205,000; tramway, 1,681,949,000. The number of third-class railway passengers carried in the United Kingdom exceeds the total number of passengers carried on the American railways. This is due largely to the fact that the regular railroad lines control a great deal of the suburban business which in America is left to the trolley lines.

It is stated that the Camden & Trenton Electric Railway, of New Jersey, will shortly install a block system on its line.

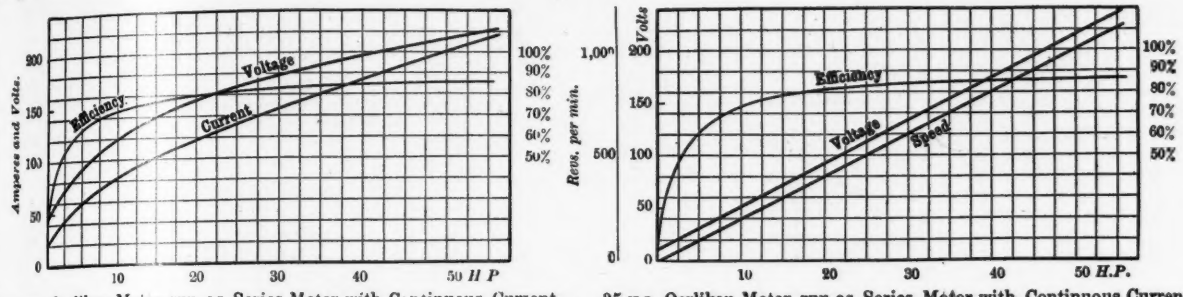
A New Single-Phase Railway Motor.

In a recent publication, Dr. Hans Behn-Eschenburg describes two single-phase commutating motors manufactured by the Oerlikon Company. An abstract of this article is given in the London *Electrician* for September 9, from which the following notes and diagrams are taken. One of these motors is rated at thirty-five horse-power, and is capable of working with continuous current or with alternating current at frequencies between twenty and forty cycles per second. The second motor is designed for 200 horse-power and a frequency of fifteen cycles per second.

The smaller motor runs normally at about 1,000 revolutions per minute, and it may be run as an ordinary continuous-current series motor from a 200-volt supply; as a series motor for single-phase currents at 200 volts and frequencies from zero to twenty-five; as a repulsion motor when fed with single-phase currents from forty to fifty cycles per second at a pressure of 230 volts; or as a compensated series motor of the Latour type, being fed in this case with single-phase current at 250 volts. The rotor and stator of this machine are each equipped with a six-polar distributed winding embedded in slots, resembling the ordinary winding of a continuous-current armature. No resistance is inserted between the armature coils and the respective commutator segments. When run as a compensated series motor, twelve brushes are necessary, but when operated in any one of the other three ways but six brushes are required. Carbon brushes eight millimetres wide are used in all cases. When used as a simple series motor, either for continuous or alternating currents, the brushes are fixed at the neutral points and the stator winding is split up into two identical parts, the magnetic axes of which are shifted relatively to each other by one-half of the pole pitch. One winding serves for producing the magnetic field, while the other nullifies the armature reaction.

For employment as a repulsion motor, or as a motor compensated on the Latour system, the two parts of the stator winding are connected together so as to form one evenly distributed winding. The air-gap of this machine is one millimetre wide.

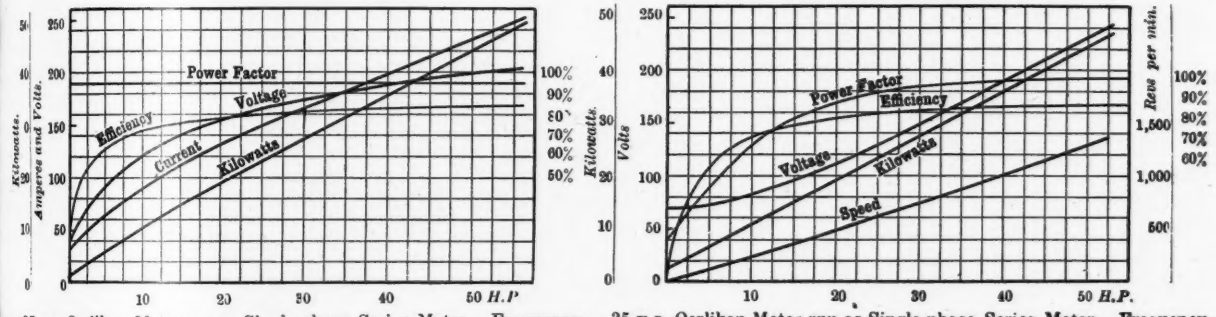
Tests of this motor, when operated in the various ways enumerated, were made, the results of which are shown in the accompanying diagrams. In every case the



35 H.P. Oerlikon Motor run as Series Motor with Continuous Current. Speed 1,000 revs. per min.

35 H.P. Oerlikon Motor run as Series Motor with Continuous Current, the Current being kept constant at 200 amps

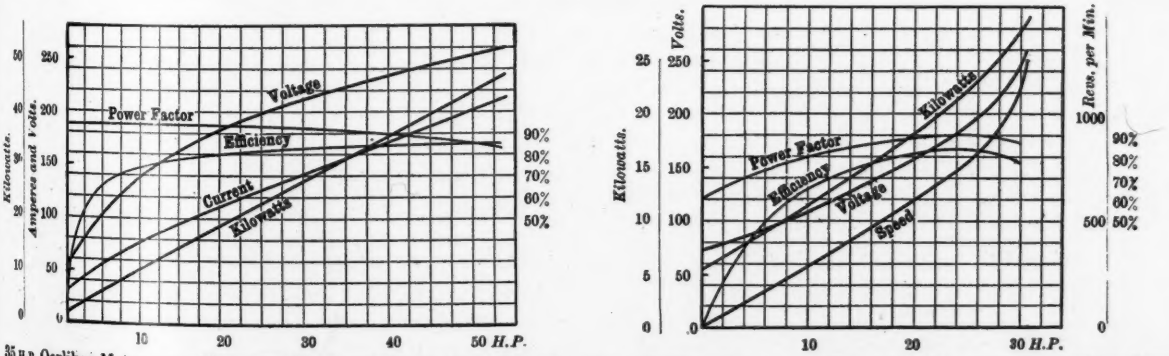
FIG. 1.



35 H.P. Oerlikon Motor run as Single-phase Series Motor. Frequency 22∿ per sec. Speed 1,000 revs. per min.

35 H.P. Oerlikon Motor run as Single-phase Series Motor. Frequency 22 ∿ per sec. Current constant at 200 amps.

FIG. 2.

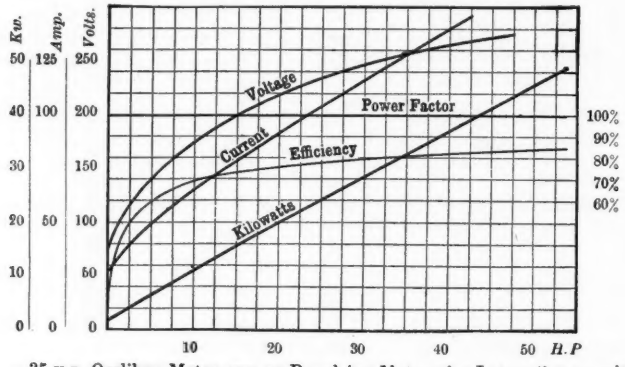


35 H.P Oerlikon Motor, run as Repulsion Motor with Single-phase Current. Frequency of 44 ∿ per sec. Speed 880 revs. per min.

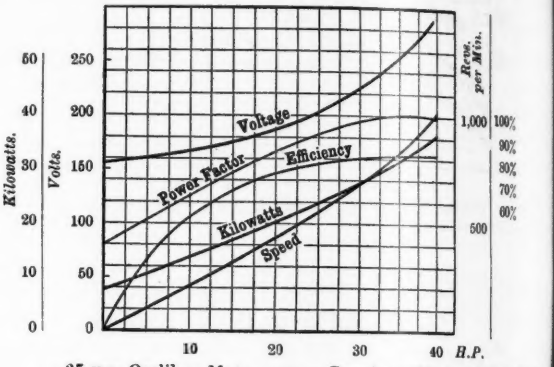
35 H.P. Oerlikon Motor, run as Repulsion Motor with Single-phase Current. Frequency 44∿ per sec. Current Constant at 130 amps.

FIG 3.

normal load, which is defined as the maximum load compatible with good commutation, was kept up for four hours. It is said that the temperature rise at the end of the run did not, in any case, exceed forty-five degrees centigrade in any part of the machine. When operating as a repulsion motor the brushes were shifted one-tenth of the pole pitch from the magnetic axis of the stator winding. This motor carcass be split; hence pole pieces similar to those for ordinary continuous-current motors were employed. It is said that this motor commutates well for all speeds between zero and 1,100 revolutions per minute and frequencies varying from fifteen to twenty-five cycles per second. The motor weighs 6,600 pounds and develops 200 horse-power when consuming 600 amperes at 260 volts. At a speed



35 H.P. Oerlikon Motor, run as Repulsion Motor of "Latour" type, with Single-phase Current. Frequency 44 ∿ per sec. Speed, 880 revs. per min.



35 H.P. Oerlikon Motor, run as Repulsion Motor of "Latour" type, with Single-phase Current. Frequency 44 ∿ per sec. Current constant at 130 amps.

FIG. 4.

position was found experimentally, and corresponded to the maximum power-factor when the motor was developing thirty-five horse-power and running at a speed of 1,000 revolutions per minute. It will be noticed from an examination of the characteristics that the efficiency of the motor when running with continuous current is about three per cent higher than with alternating current. The power-factor of the ordinary single-phase series motor is three per cent better than that of the repulsion motor. For speeds from 800 to 1,000 revolutions per minute the commutation was excellent for all four ways of working, but for speeds below 500 revolutions per minute and above 1,000 the commutation was good only when the motor was running as a continuous-current or alternating-current series motor. In the other two cases special arrangements have to be provided to reduce sparking. The motor weighs, without gearing, 2,200 pounds.

The second motor was designed for 200 horse-power, a normal speed of 650 revolutions per minute and a frequency of fifteen cycles per second. It is one of two motors intended for a locomotive which, at a speed of twenty-five miles an hour, requires approximately 400 horse-power to drive it. These motors are to replace continuous-current motors already existing, and their design had to conform to certain conditions. It was necessary that the of 650 revolutions per minute, the frequency being fifteen cycles per second, the power-factor was 0.94 for all loads. At a speed of 1,100 revolutions per minute, and at the same frequency, the power-factor was 0.97. When the frequency was increased to twenty-five cycles per second, the corresponding figures for the power-factor are given as 0.87 and 0.93, respectively.

High-Tension Direct Currents.

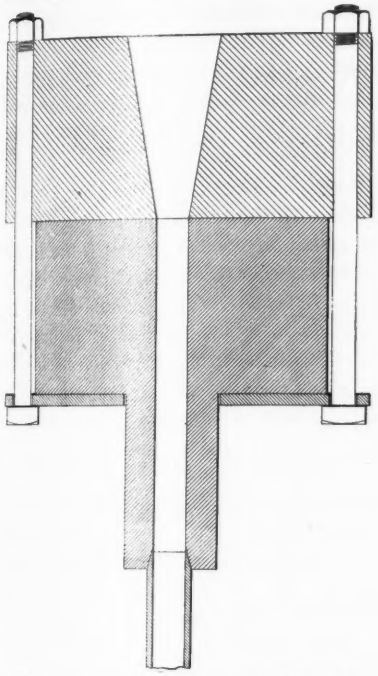
A transformer for producing high-tension unidirectional currents suitable for experimental work and for exhausting Rœntgen tubes has been constructed by F. J. Koch, of Chemnitz. The new apparatus gives impulses of fairly long duration. It is, in fact, a rectifier. The primary of this transformer includes resistance and inductance, both of which may be varied. The secondary includes a long spark-gap terminating in two electrodes, between which is revolved a needle. In this way the spark-gap is divided into two parts, whose length varies during each revolution. The needle is driven by a synchronous motor, so that the length of the two spark-gaps varies in synchronism with the phase of the primary current. The action of the needle is to cut out those half-waves which are not in the proper direction, and to allow only those having the correct direction to pass at their maximum pressure. The ratio of transformation may be varied from 1 to 1,000, to 1 to 1,450. The effect of the inductance of the primary circuit is to prevent undesirable arcing at the secondary spark-gap. When the inductance is in circuit, the arc is broken up into a stream of sparks. With this transformer, sparks forty-two centimetres long are obtainable. The maximum potential difference is 140,000 volts. The transformer is immersed in oil. The apparatus can be operated from a continuous-current supply by means of a small rotary converter, which, at the same time, takes the place of the synchronous motor driving the rectifier needle.

Electric Railroad in Peru.

It is reported by United States Consul Alfred Gottschalk, of Callao, Peru, that the electric railroad between Lima and Callao is now in operation. This is the second undertaking of this kind in Peru, the first being that running between Lima and Chorillos, and other seaside resorts. The new road is operated by the overhead trolley system, and is eight miles in length. This distance is covered in a little over twenty minutes. The cars run every fifteen minutes. The fare charged is one-half of that formerly required on the steam railroad. This road has, so far, not been able to obtain permission to run through the principal streets of Lima, and it now stops at Union street, the chief commercial artery, where it connects with the horse-car lines. It is thought, however, that the objections to electric traction through the streets of the city will soon be overcome. The road runs through the main streets of Callao, and has a spur about a mile and a half long running to La Punta and seaside resorts.

Electrical Patents.

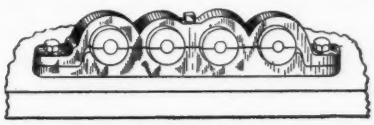
Henry Noel Potter, of New Rochelle, N. Y., has assigned to George Westinghouse, of Pittsburg, Pa., a patent recently obtained by him on a compensating terminal for electric furnaces. The object of the invention is to provide a compensating terminal, by the use of which the different expansion of the parts constituting the terminal are prevented from causing disturbing variations of pressure.



COMPENSATING TERMINAL FOR ELECTRIC FURNACES.

In carrying out the invention, a core or furnace-body of graphite or other form of carbon is employed, also a terminal of similar material making good mechanical and electrical contact therewith. The part is provided with a flange or enlargement and its outer end makes contact with a terminal of copper, brass, or other material. The parts are joined by bolts which may be of steel or iron, suitable washers being interposed to assist in making the connection. The essential thing in connection with apparatus of this sort in order to make the terminal a "compensating" terminal is that the bolts should have an expansion coefficient intermediate between that of the terminals. Then, by properly dimensioning the parts, the terminal can be so constructed as to be self-compensating, that is to say, the reactions of the parts under the influence of heat will just balance each other, so that the pressure between the parts will remain practically constant under actual variations of temperature. The following will serve as a concrete example of such a compensating terminal: assuming that the terminal will be raised to 300 degrees centigrade by the operation of the furnace and that the flange is ten centimetres in thickness at zero degrees, if the coefficient of expansion of graphite between zero and 300 degrees is 0.2691 per cent the flange will be 10.026913 centimetres in thickness at 300 degrees. Assuming that the coefficient of copper between zero and 300 degrees is 0.57105 per cent and that of iron is 0.42405 per cent, then it may be readily calculated that if the terminal be of copper and be 10.47 centimetres in length, then the expansion of the flange plus that of the terminal will be just equal to the expansion of the bolts throughout that portion of their extent in which their expansion is capable of effecting the pressure between the flange and terminal.

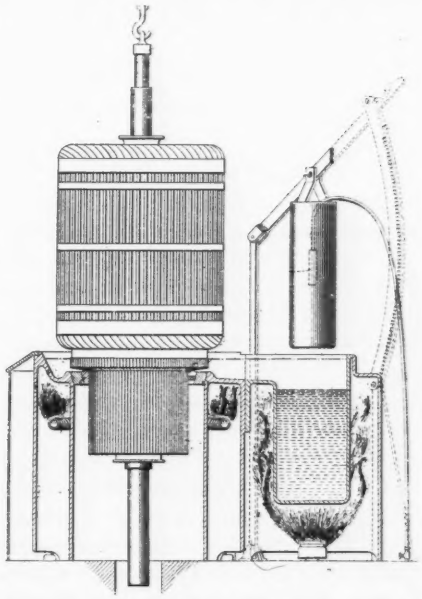
An improvement in insulation racks, consisting of two or more bents and designed to hold two or more sets of split insulations, has already been patented by Mr. John R. Fletcher, of Dayton, Ohio. In embodying this invention, each rack is constructed of two parts which



INSULATION RACK.

have the desired number of bents or openings for the requisite number of sets of split insulators, which consist of porcelain. The ends of the racks terminate in matching flanges and each rack is adapted to hold two or more sets of split insulations with openings of uniform or different diameters and which may be constructed of any insulating material. The parts of the rack closely surround the insulation parts and hold the same uniformly, so that any danger of breakage is avoided. The openings in the racks are of sufficient diameter to prevent any lateral or shifting movement of the two parts of the insulations. The two members of the rack are united at their ends by bolts which pass through the openings in the ends of the racks and are secured in positon on a wall, ceiling, or other suitable place. In the event that the rack contains openings for a greater number than three sets of insulations, the central portions of the rack are secured by means of a screw or bolt.

Jacob Beech, of Wilkinsburg, Pa., has assigned to Westinghouse Electric and Manufacturing Company, of Pennsylvania, a patent which he recently obtained on a method of soldering armature-leads to commutator-bars. The apparatus comprises a frame having two concentric cylindrical shells which rest upon a suitable floor or base and which are connected at their upper ends by a web of such form as to provide an annular basin, the outer edge of which is considerably higher than the inner edge. The two shells and the web are integral parts of a single casting. One shell is nearly surrounded by a casing, and between the two shells is located a gas-burner. The inner wall of the web is provided with a tapering or inclined surface, against which is fitted a master-ring, the inner diameter of which corresponds to the outer diameter of the commutator, to the necks of which the solder is to be applied. The necks of the commutator-bars rest upon the ring, and the commutator-body and the corresponding end of the shaft project down into the interior of the cylinder. The armature and its shaft and commutator may be placed in position by means of a suitable crane, the lifting-hook of which is connected to one end of the shaft by any suitable connecting device. The solder to be applied is contained in a pot, between which and the basin is a channel, this pot being surrounded by a casing, within which is a



METHOD OF SOLDERING ARMATURE-LEADS TO COMMUTATOR-BARS.

flame for maintaining the solder in a molten condition. This flame is supplied by a gas-burner located below the pot. In order to cause the molten solder to flow to and from the basin a plunger is provided suspended from a lever, one end of which is pivotally supported by a rod or bar and the other end of which has a handle and a pawl. The bar extends between two parallel grooved arms, one of which is provided with ratchet-teeth in position to be engaged by the pawl so that the plunger may be lowered notch by notch and fastened in any position desired in order to secure the desired level of molten solder in the basin.

Reviews of Current Engineering and Scientific Literature.

Roentgen Rays in the Manufacture of Cables.

A very neat application of Rœntgen rays in cable manufacture is here described by Herr W. Otto. The chief value of this apparatus is in detecting foreign substances and imperfections in the rubber or gutta-percha insulation of electric cables. The apparatus is of particular value in preparing submarine cables, since here defects which might ultimately give much trouble and cause great expense for repair are easily detected. The device consists of a table containing the necessary regulating apparatus. On this a Rœntgen tube is fixed, and above it is placed the fluorescent screen. The cable to be examined is passed through guides which conduct it just below the screen, so that the shadow of the cable is thrown upon the screen. This arrangement allows the cable to be passed through the testing apparatus quickly. Any foreign substances or a bubble of air, or even a bad joint in the rubber, is at once shown. It is convenient to have the apparatus portable, so that it may be taken to any part of the works.—*Translated and abstracted from Electro (Brussels), August.*

Remarks upon the Electrolytic Dissolution of Platinum in Hydrochloric Acid.

M. D. Tommasi here describes some experiences of his when using platinum electrodes in hydrochloric acid. He has found that if the acid is at its maximum concentration, the platinum is attacked and behaves as a soluble anode. If, on the contrary, the acid is dilute, it is not attacked. The electrolyzing vessel used in these tests was formed of a U-tube, in the branches of which were placed the two chemically pure platinum electrodes. Current was furnished by two Daniell cells connected in series. With a concentration of the hydrochloric acid giving a specific gravity of 1.18, hydrogen was set free at the cathode, but there was no disengagement of the gas at the anode. At the end of one hour small bubbles of gas collected upon the latter electrode. After twenty hours hydrogen was still set free at the cathode, and oxygen came off at the anode. Upon evaporating the liquid and calcining the residue in an atmosphere of hydrogen, pure platinum was obtained. Upon using different concentrations of hydrochloric acid with the same electrolyzing potential, the same results were obtained until the concentration was reduced to ten per cent of acid of the density mentioned above. With an electrolyte formed of five cubic centimetres of this acid and 100 cubic centimetres of distilled water, upon electrolysis, gases were at once given off at both electrodes. Continuing the electrolysis for 100 hours, and then evaporating the solution, no trace of platinum was discovered. The same results were obtained with solutions of decreasing acidity down to one per cent.—*Translated and abstracted from L'Électricien (Paris), September* 10.

The Magnetic Reluctance of Air Cores in Short Coils.

The construction of air-core transformers is usually a matter of trial and error. In this article Dr. W. M. Thornton gives some formulæ which enable the coils to be predetermined with a fair amount of accuracy. If the distribution of magnetism along the axis of a short-air core-coil be explored, it is found that the magnetic lines diverge on either side of the centre, so that the flux density within the core falls rapidly toward the ends. The reluctance of the coil may be found experimentally. To estimate it, the assumption may be made that the whole magnetic circuit is numerically equal to that of the mean cylindrical air-core enclosed by the coil. The value found in this way may be called the apparent reluctance, and the ratio between the true reluctance determined experimentally, and the apparent reluctance denotes the effect of the lines bending back through the winding, and may be called the dispersion coefficient of the coil. This coefficient is the same for any given proportion of winding, whatever its dimensions. To determine the value of this coefficient a set of coils was made, each having the same internal and external diameters. Their lengths increased in steps until the ratio of length to the external diameter was three to one. Experimental work with these coils showed that the impedance of coils whose length exceeds their diameter is strictly proportional to their length; below this it is slightly in excess of the proportionate values. It is only with the longer coils that there is much difficulty in obtaining exact calculations, and the experiments show that in these both impedance and reluctance are proportional to the length over the greater part of range examined. The reluctance is also proportional to the length beyond the point where the length equals the diameter. This result simplifies the calculations of air coils. The dispersion coefficient reaches a constant value at about the ratio of three to one, showing that in longer coils than this the effect of the ends can be ignored. For coils having the same relative external and internal diameters—which, in this case, were two to one—the inductance can be calculated by the formula, $L = 4\ \pi\ t^2\ R$, where R is equal to $\delta \frac{l}{A}$, δ being the dispersion coefficient, and having a constant value of 0.605. In these formulæ t is the number of turns; R, the reluctance; l, the length of coil, and A, the average cross-sectional area of the core. The formula for the reluctance may be simplified by incorporating the value for the dispersion coefficient in the expression for mean area. The value found in this way is then equal to $0.25\left(d\frac{1}{2} + d\frac{2}{z}\right)$. Dividing this expression into the length of the coil gives its reluctance at once. For predetermining the inductance of shorter coils, the author advises the use of the formula given in Maxwell's "Electricity and Magnetism."—*Abstracted from the Electrician (London), September* 16.

Auxiliary Electrodes in Lead Accumulators.

The different types of auxiliary electrodes which have been found useful in steadying and maintaining lead storage batteries are discussed in this article by M. Ch. Liagre. There are a good many materials which might be used for this purpose, but the questions of convenience make certain properties desirable. The electrode should be of some material which is insoluble in the acid of the cell, because it may be necessary to leave it in the electrolyte for some time, and if it is insoluble it will not introduce any impurities. If instantaneous measurements only are desired, zinc may be used, but cadium is a little better, as it is not attacked as freely as the zinc. A hydrogen electrode is frequently convenient. This is formed by coating a strip of platinum with platinum black, and then allowing it to stand in hydrogen. This process is carried out by placing the platinum back in dilute sulphuric acid, through which hydrogen is passed. Mercury may also be used for an auxiliary electrode. An electrode of this kind is prepared by

placing mercury in a small glass vessel, with which contact is made through a capillary tube. The mercury is covered with a paste formed of mercurous sulphate and sulphuric acid. The apparatus thus prepared is introduced into the cell. Auxiliary electrodes of these kinds polarize rapidly, and are thus not suitable for measurements where currents must be drawn through the electrode. An electrode which does meet this condition may be formed of lead, coated with lead peroxide. A small piece of a discarded lead plate makes a very satisfactory electrode. Before being used it should be fully charged and kept in acid of the same density as that of the cells which are to be examined. This article contains a number of tables and curves showing the electromotive force given when using auxiliary electrodes of different kinds in cells with acid of different concentrations, and under different conditions of charge.—*Translated and abstracted from L'Eclairage Electrique (Paris) September 10.*

The Electrical System of the Midland Railway at Heysham Harbor, England.

The Midland Railway Company has erected an important power-station at Heysham Harbor for conducting the work connected with the docks. The power plant consists of three gas-driven continuous-current generators. The gas for driving the engines is obtained from a Mond producer, and after the necessary cleansing, is used in three 150-horse-power Westinghouse standard gas engines. These are of the three-cylinder vertical single-acting type, and operate at 200 revolutions per minute. The engines are started by means of compressed air stored in a battery of tanks, charged by means of two motor-driven air-compressors. The generators are of the continuous-current type, giving a voltage of 430 and 325 amperes at normal load. The auxiliary apparatus consists of a storage battery of 115 cells, which will deliver 180 amperes for six hours. These are charged and discharged in connection with two battery boosters. There is also a balancer and a power and lighting feeder booster. The battery boosters are automatically reversible. They consist of a shunt-wound motor driving a sixteen-kilowatt booster generator and a small five-kilowatt exciter. The booster motor is connected in series across the three-wire system. The booster itself is separately excited, the exciter being a differently compound-wound machine. This station supplies power for lighting all the docks and for operating cranes and capstans. A feature of interest in connection with the work is the lighting installation. The rise and fall of the tide at Heysham Harbor is about twenty-five feet. This made necessary three landing stages. The lower and middle of these are submerged regularly twice a day. The lighting wires for these stages are run in galvanized screwed heavy-gauge steel piping. The lamps are enclosed in specially designed water-tight fittings. The elevators provided for the use of passengers and freight are fitted with water-level cutoffs, making it impossible for the elevator to come down to the lower landing stage when this is below water. The elevator cars are, moreover, buoyant, so that, should they happen to fall to the water, they would float.—*Abstracted from Engineering (London), September 2.*

Comparison between Direct-Current and Polyphase Systems for Electric Hoisting.

Mr. J. G. Hooghwinkel has made a comparative study of the advantages and disadvantages of direct and alternating-current systems of hoisting in mines. The condition to be considered first is the efficiency and cost of the two systems. As against the polyphase system, we have the poor stopping qualities of these motors and the high losses which take place at starting. There is a lack of speed regulation, and, in stopping, all the energy is wasted in brakes. The main engines must be fitted with very heavy flywheels. It is said that the losses due to starting and regulating polyphase motors amount to sixty per cent of the total energy required for each complete hoist. These losses are largely avoided with suitable direct-current equipment. If a direct-current system is used, a battery may be installed, which will enable the work to be done with a smaller station equipment, and which will maintain a fairly uniform load on the generators, thus raising the economy of generation. A battery equipment also makes simple the saving of energy given up in braking and stopping. The main engines need only supply the average power and a sufficient amount of energy to overcome the static forces. The saving in the output of the steam sets largely balances the cost of the battery, a battery costing about half the price of a steam equipment. It is said that at the Tiederhall mine, for every horse-power useful load lifted at the shaft the required power at the engine was from 2 to 2.2 brake-horse-power. For a three-phase system the author has found the equivalent figure to be 3 to 3.25 brake-horse-power. This was at the Hohenegger mine, which has the same output as the one mentioned above. If a battery be used, certain complications become unavoidable, but these may be minimized by the use of a starting motor-generator, which will regulate the charge and discharge of the battery. These machines are about half the size of the winding motor, and by their use any position of the controlling lever of the winding machine corresponds to a fixed speed which does not vary even when lowering materials. This is an important advantage. When a starting motor-generator is used, the regulating apparatus is small, being only inserted in the shunt circuits. A combination of a starting motor-generator and the Ward Leonard system of separate excitation, combined with the use of a high-speed flywheel on the motor-generator, has been introduced under the name of the Ilger system. This system can be used with any supply of any frequency. Summing up the comparison, the author finds that the capital outlay with either system is about the same. The steam and fuel consumption is thirty per cent less with a continuous-current plant. There are no losses due to a heavy flywheel on the engine. He says that this estimate of thirty per cent saving has been found to be correct in actual practice. He is also of the opinion that there is a greater security and easier and more perfect speed regulation with a direct-current system; and when it is used with a suitable auxiliary device, the lighting of the buildings can be supplied from the same plant. When the mine does not have its own power plant, but draws a large high-tension station supplying several mines or districts, the fluctuations in load due to hoisting are not so noticeable. However, the starting losses remain, and as these are from forty to fifty per cent of the total energy, the author is of the opinion that even here a continuous-current plant with a starting motor-generator and a high-speed flywheel has decided advantages. It would soon pay back the extra cost of the continuous-current plant, which is slightly more in such a case. Should the hoisting load be but a very small part of the total load on the station, the three-phase motors may be employed.—*Abstracted from the Electrical Engineer (London), September 16.*

Quick Time in the Subway.

On Monday afternoon, October 3, a special train carrying representatives of the New York daily press and the technical journals was run through the subway. The guests, by invitation of the management of the Interborough Rapid Transit Company, assembled at the City Hall station at 2.30, where a train awaited them. There were about 150 who took the trip. Vice-president E. P. Bryan and General Manager Frank Hedley were in charge of the party. A number of the company's engineers were also present.

The train was made up of six cars. The leading and rear cars were the new steel type, the interior of which has an aluminum finish. The remaining cars were of the type which has been in use on the Second Avenue line, and are sheathed externally with copper. The seating arrangements are similar to those on the elevated lines, there being in each car seats for fifty-two passengers and a liberal number of straps.

After a slight delay, due to the tardy arrival of some of the guests, the train got under way and rounded the curve at the City Hall station. The starting point of the run was really the Brooklyn bridge station, which was left at 2 37:50 P. M. The train was run as an express to Ninety-sixth street. The cars ran very easily, and the passengers on the train would not have realized the high speed which was attained were it not made evident by the rapidity with which the stations flashed by. The curve at Fourteenth street was taken without slackening speed, and the Grand Central depot, at Forty-second street, was reached in five minutes and forty seconds. The Ninety-sixth street station, where the train was slowed down, was reached in ten minutes and forty-five seconds. After a brief stop the train ran up the west branch to One Hundred and Forty-fifth street, reaching there at 2.54:50, just seventeen minutes after the start. The train then returned to the Ninety-sixth street station, and ran up the east branch to the yards. The return was made at a reduced speed to Ninety-sixth street, and from there on stops were made at all the stations, the train running as a local. The guests were allowed to get off and inspect several of the stations.

During the trip the train passed a good number of other trains, which are being run in order to break in the motormen and conductors. The work on the stations is rapidly nearing completion, the roadbed seems to be finished, and the signaling system is in operation. Upon entering and leaving the City Hall station the difference in temperature was very noticeable. The day was quite cool, and the air in the subway was considerably warmer, without, however, being close.

STREET RAILWAY WEEK AT ST. LOUIS.

THE ANNUAL MEETINGS OF THE AMERICAN STREET RAILWAY ASSOCIATION, THE AMERICAN RAILWAY, MECHANICAL AND ELECTRICAL ASSOCIATION, AND THE STREET RAILWAY ACCOUNTANTS' ASSOCIATION OF AMERICA.

The week of October 10 will be Street Railway Week at the World's Fair, St. Louis. The American Street Railway Association will hold its twenty-third annual meeting October 12 and 13, on the second floor of the Transportation Building in the exposition grounds. Papers will be presented on such subjects as "Steam Turbines," "Reciprocating Engines," "Gas Engines," "Transfers, Their Uses and Abuses," and "Signals."

The American Railway, Mechanical and Electrical Association will hold meetings on October 10, 11 and 14. These meetings will be held on the second floor of the Transportation Building. Papers will be read by John Lindall, on "Maintenance and Inspection of Electrical Equipment"; by J. Millar, on "Wheel Matters," and by W. D. Wright, on "The Ideal Shop." In addition to this there will be the Question Box and the joint discussion with the Street Railway Accountants' Association on "Blanks for Shop Records and Accounts."

The meetings of the eighth annual convention of the Street Railway Accountants' Association of America will be held as follows: Thursday, October 13, in the parlor of the Inside Inn; Friday and Saturday, October 14 and 15, on the second floor of the Transportation Building.

October 12 has been designated as Street Railway Day by the officials of the World's Fair. It is expected that addresses will be made by the president, the Hon. D. R. Francis, Mayor Rolla Wells and Professor W. E. Goldsborough.

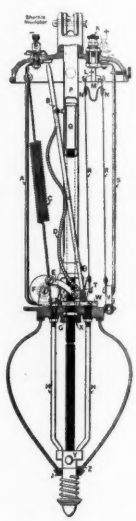
The manufacturers' committee has prepared a fine programme of entertainment. There will be a special musical concert at the hall before the opening of each session, and numerous concerts during the week.

The transportation committee of the American Street Railway Association has arranged for a special train to St. Louis, *via* the Pennsylvania Railroad, leaving New York at 10 A. M., Saturday, October 8, arriving at St. Louis the following day at one o'clock. This train will consist of Pullman buffet, smoking and drawing-room sleeping cars, and will stop at Trenton, Philadelphia, Harrisburg, Pittsburg, etc.

An Arc Lamp with a Hot-Wire Control.

An arc lamp, the feed and regulation of which are controlled by a hot wire, has been brought out recently in England. The following description is taken from the London *Electrician*:

Referring to the accompanying illustration, the current enters the positive terminal, shown dotted, and passes down the lead S, to the post V. To this post are attached two pairs of metal strips RR, the expansion and contraction of which control the feed of the carbon. The upper ends of the strips are fixed to the stirrups NN, which are hung from the rocker M, on the post L, the height of which is adjustable by the screw K, enabling the tension of the strip to be regulated. To prevent sparking at the rocker the strips are connected across just above the stirrups, as shown. The bottom ends of the strips are attached to a hook T, from which connection is made by the flexible wire D, to the upper carbon holder Q, and are free to slide in the tube P. This holder is merely a split tube, and the positive carbon is pushed home into it. The circuit from the negative or lower carbon is through the carbon holder Y, the bottom rods HH and the negative lead A, to the negative terminal. When current is turned on the strips expand; and as the bottom hook T is fixed to the end of a rigid strut B, pivoted at its upper end, the hook is pulled over to the left by the spring C, acting through the disc F and the link E. As the disc rotates it moves the lever U, shown dotted in the drawing, and thus brings into action the clutch W, which lifts the positive carbon and strikes



ARC LAMP WITH HOT-WIRE CONTROL.

the arc. There is a certain amount of play between the link U and the disc F, so that the wire is allowed to attain a fairly high temperature before the arc is struck. With a diminished current the heated strip shortens, and the disc is turned slightly, allowing the carbon to feed. Should the feed of the lamp prove too fast or too slow, it may be adjusted by the screw K. The lamp is fireproof, and contains no solenoid or dashpot. The upper carbon is guided by a steatite ring G, screwed into the bushing X and the clutch is lined with the same material.

This lamp has been tried by the Wimbledon Urban District Council Electricity Works, where fourteen or fifteen have been burning on a fifty-cycle alternating current during the last eighteen months. They have given such satisfaction that an additional number of the latest type have been ordered. This lamp has an advantage, in that it operates equally well on alternating currents of any frequency, or upon direct currents. It is made by Messrs. Foster & Company, of Worple road, Wimbledon, England.

American Electrotherapeutic Association.

The officers elected at the St. Louis convention of the American Electrotherapeutic Association, held recently, are as follows: president, Emil Heuel, M. D., New York city; first vice-president, Charles Hamilton Hughes, M. D., St. Louis, Mo.; second vice-president, Morris Weil Brinkmann, M. D., New York city; treasurer, Richard Joseph Nunn, M. D., Savannah, Ga.; secretary, Clarence Edward Skinner, M. D., New Haven, Ct.; members of the executive committee, Fred Harris Morse, M. D., Boston, Mass.; Charles Olin Files, M. D., Portland, Me.; Thomas Davidson Crothers, M. D., Hartford, Ct.; Daniel Roberts Brower, M. D., Chicago, Ill.; A. D. Rockwell, M. D., New York city; Charles R. Dickson, M. D., Toronto, Canada.

The choice of the next place of meeting has not yet been announced.

The feature of the convention was the admirable report of the work done by the committee on current classification and nomenclature. This committeee consisted of William J. Jenks, New York city, chairman; Professor Elihu Thomson, Lynn, Mass.; Professor Samuel Sheldon, Brooklyn, N. Y.; and Dr. Charles L. Clarke, of Bronx Borough, New York city. The work of this committee is of great importance to electro-physicists and electrotherapeutists.

Group Photograph of the Officers and Directors of the National Electrical Contractors' Association.

At the recent meeting of the National Electrical Contractors' Association, held at St. Louis, Mo., September 14, 15 and 16, officers and directors were elected. We reproduce herewith a group photograph of the official representation of this organization, which is composed as follows:

Mr. E. McCleary, 213 Jefferson avenue, Detroit, Mich., president.

Mr. W. I. Gray, 804 Sykes Block, Minneapolis, Minn., first vice-president.

Mr. Walter C. McIntire, 506 Commerce street, Philadelphia, Pa., second vice-president.

OFFICERS AND DIRECTORS OF THE NATIONAL ELECTRICAL CONTRACTORS' ASSOCIATION.

Mr. J. P. Coghlin, P. O. Box 884, Worcester, Mass., third vice-president.

Mr. John R. Galloway, 529 G street, N. W., Washington, D. C., treasurer.

Mr. W. H. Morton, 44 Whitesboro street, Utica, N. Y., secretary.

Mr. J. C. Sterns, 255 Pearl street, Buffalo, N. Y., sergeant-at-arms.

THE BOARD OF DIRECTORS.

New York—James R. Strong, 35 South William street, New York city; M. L. Barnes, 273 River street, Troy.

Pennsylvania—E. R. Keller, Philadelphia.

Michigan—F. J. Miner, 207 Jefferson avenue, Detroit.

Minnesota—E. A. Richardson, Minneapolis.

Maryland—H. K. McKay, Baltimore.

Missouri—F. E. Adam, St. Louis.

Indiana—G. M. Sanborn, Indianapolis.

Washington, D. C.—E. C. Graham.

Ohio—E. M. Lawton, Cincinnati.

Illinois—Arthur Frentzen, Chicago.

Connecticut—H. E. Page, Hartford.

Massachusetts — Seth B. Witherbee, Boston.

Wisconsin—George C. Rohn.

Iowa—Edward Kunkel, Des Moines.

Arkansas—T. B. Martin, Jr., Little Rock.

The Distribution of Extra International Electrical Congress Papers.

Members of the International Electrical Congress can receive extra copies of any congress paper or papers in which they are interested, and which were printed in advance, by applying to Mr. H. H. Humphrey, electrical engineer, Chemical Building, St. Louis, Mo. Mr. Humphrey has promised to distribute these papers on application until October 10. It is also announced that written communications, by way of discussion, from congress members on any congress paper will be received by the general secretary of the congress, Dr. A. E. Kennelly, Harvard University, Cambridge, Mass., up to October 15.

Single-Phase System in England.

An experimental single-phase motor system is being built by the British Westinghouse Company at its works at Trafford Park, Manchester, England. The development of this system will be watched very closely by the British railroad interests.

INDUSTRIAL SECTION.

ILLUSTRATED DESCRIPTIONS OF NEW AND STANDARD ELECTRICAL AND MECHANICAL APPARATUS.

The Hamilton-Holzwarth Steam Turbine.

The Hooven, Owens, Rentschler Company, of Hamilton, Ohio, has developed a new machine designated as the Hamilton-Holzwarth steam turbine. One of these machines—a reproduction of which is shown in the accompanying illustration—is now on exhibition and in operation at the World's Fair, St. Louis, in block 46, Machinery Hall. This is a 10,000-kilowatt turbine, direct-connected to a 10,000-kilowatt generator, and was designed to operate under 185 pounds initial steam pressure; speed, 1,500 revolutions per minute, with twenty-eight inches vacuum.

For units of 750 kilowatts and upward the rotating body is divided into two parts, making a high and low-pressure turbine. Smaller units are built in one turbine casing. The turbine casings and pedestals for the bearings and the generator are placed upon a rigid bed-plate of the box pattern. All steam, oil and water piping is within and below the bed-plate.

After passing through the steam separator, which is located below the bed-plate, the steam passes through the main inlet valve. The valve has an extended stem, which is connected with a floor-stand and hand-wheel located on the floor close to the high-pressure end of the turbine. Steam then passes through the regulating valve, and from there through a curved pipe to the head of the high-pressure turbine. From the ring channel of this head the steam flows through the first set of stationary vanes, which changes its direction and imparts the necessary velocity. These vanes are rigidly connected to the head. From here the steam flows in a full cylindrical belt, interrupted only by the vanes of the first running wheel, and from the first running wheel to the following stationary discs, and so on.

From the last running wheel the steam is led through pipes to the front head of the low-pressure casing, or, if there is only one casing, immediately to the condenser.

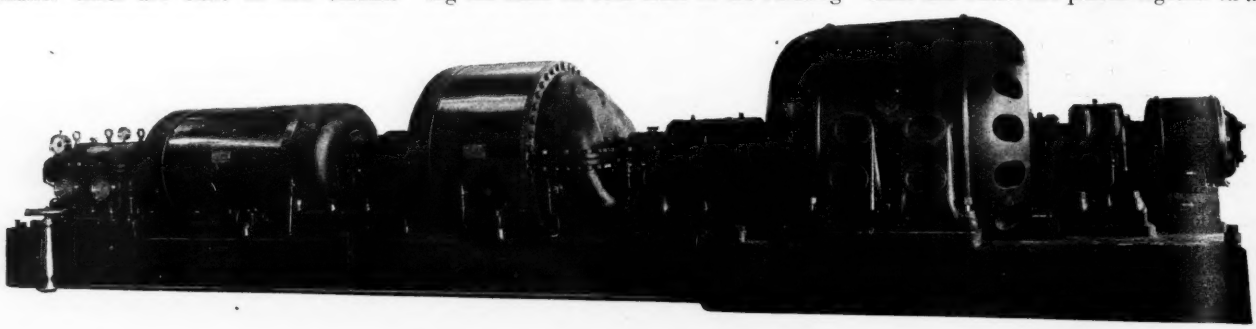
The design of this turbine consists essentially of a plurality of stationary discs and running wheels. The stationary discs and running wheels have vanes all around their circumference. The characteristic of this turbine, however, is that steam is expanded only in the stationary blades. The radial height of the vanes of the stationary blades is increased to correspond to the volume to which the steam is expanded. Balance pistons are left out, because the axial thrust of the running-wheel shaft is easily taken up by the thrust ball-bearing, the steam pressure being the same on both sides of the running wheel. The whole rotating part is balanced, and the shaft is designed, so as to keep it far below the angular speed at which it would be apt to vibrate.

The purpose of the stationary disc is to prepare the steam for its action in the power-transmitting part (the running wheels) of the turbine. As the stationary discs do not move, the back pressure of the impinging force of the steam is exerted in the running wheels. Within the vanes of the stationary discs the steam has to expand to accelerate and to change its direction with the best possible efficiency. The stationary discs are located in grooves in the turbine casings. The vanes are drop-forged steel, milled and located in a groove on the outside periphery of the discs. The vanes are fastened to the discs by rivets. After being fastened, the disc and vanes are ground on their outside edges, giving the vanes the profile they should have for efficient steam expansion. After this a tough steel ring is shrunk on the outside periphery of the vanes and steam channels.

The running wheels are built with cast-steel hubs. Steel discs are riveted to both sides of this hub, forming circumferential ring space into which the vanes are held by means of rivets. On the outer edge of the vanes a thin steel band is tied around the wheel, in order to give an outside wall to the steam channels.

The bearings for the turbine shaft have much less weight to support than those of the generator shaft, and, therefore, can be made short, with straight cylindrical shells, while it is necessary that the bearings of the generator have ball-shaped shells to ensure alignment with the shaft. In both kinds of bushings or shells the top and bottom vanes are screwed together. The pedestals and the caps are designed in such a manner that the oil inlet and outlet are placed together on the side of the pedestal, so that no piping has to be deranged to take out the bushings. The oil flows to the bottom bushing under a slight pressure, and then flows with the rotating shaft and is taken off in the cap. From here it flows back to the oil outlet in the pedestal.

The governor is of the spring-and-weight type, especially adapted to high speed, and designed for the special purpose of steam governing. The governor is directly driven by a turbine shaft revolving with the same angular velocity. Every outside movement of the weights caused by increasing or decreasing the angular velocity of the turbine shaft is transmitted, by means of levers, to a sleeve which actuates the regulating mechanism. While the sensibility of the governor is brought to a high degree by the use of these means, it has a great amount of energy, due to the high centrifugal stresses of the weights, though these are very small. The governor forms a high-grade construction which can be used for all purposes where high angular velocity



THE HAMILTON-HOLZWARTH STEAM TURBINE.

could be effectively controlled within small limits.

With this type of turbine, one large, carefully-designed throttle valve is used. This regulating valve is located below the bed-plate. It is connected by a curved pipe with the high-pressure front head on one side, and with the inlet valve on the other side. It is of the double-seated poppet-valve type, of a special design, ensuring perfect balance. The valves and valve seats are of tough cast steel. The valve body is made of cast iron. Immediately below the regulating valve, and forming a part of it in one steam chamber, is located a bypass regulating valve. This valve has to control the quantity of the steam supply, which flows directly to the bypass nozzles in the low-pressure front head. This valve is also of the double-seated poppet-valve type. The main regulating valve is not actuated directly by the governor, but by means of a regulating mechanism. Though this indirect-acting regulating mechanism is more complicated, its application is justified when the aim for regulation is very high and when the moment of inertia of the rotating body is large.

The stem of the regulating valve is driven, by means of bevel gears, by a shaft which is supported in frictionless roller bearings. On this shaft there is a friction wheel which the governor can slide across the face of a friction disc, by means of its sleeve and bell-crank lever. This friction disc, which is continually revolving, is keyed to a solid shaft, which is driven by a coupling from a hollow shaft. The hollow shaft is driven, by means of worm gear, by the turbine shaft. The solid shaft, with the revolving friction disc, can be slowly shifted by the governor sleeve so that the two friction discs come into contact when the sleeve moves—that is, when the angular velocity changes. If this change is relatively great, the sleeve will draw the periodically revolving friction disc far from the centre of the always-revolving one, and this disc will drive quickly the stem of the regulating valve and regulate the steam flow. As soon as the angular velocity falls below a certain percentage of the normal speed, the driving friction disc is drawn back of the governor, the regulating valve remains open, and the whole regulating mechanism rests or stops, though the shaft is still running. The governor shuts down the whole turbine as soon as the angular velocity reaches a point two and one-half per cent higher than normal.

In order to change the speed of the turbine while running, there is provided a spring balance attached to the bell-crank lever of the regulating mechanism. The hand-wheel of this spring balance is outside of the pedestal of the regulating mechanism. With this spring balance the normal speed of the turbine can be changed five per cent either way.

All bearings of the entire turbo-generator are fed with a sufficient quantity of oil to ensure cool running. The oil flows from an oil tank of large capacity (the bed-plate is used for this purpose) to the oil pump, which is driven, by means of worm gearing, by the turbine itself. From this pump the oil is forced through the bearings and back to the oil tank. In the oil tank it is cleared by flowing through a strainer, and at this point it has sufficient time to radiate part of the heat to the walls of the bed-plate. The pressure pipe to each bearing can be closed by a valve, so that the flow of oil to the different bearings can be regulated.

Motor-Generators.

The increasing use of storage batteries for launches, automobiles and private lighting plants has prompted a larger demand for a compact and effieient charging apparatus. Several devices have been designed for charging various forms of storage batteries, and in some peculiar characteristics each has an advantage over the other. The manufacturer of this new line of motor-generators, the Holtzer-Cabot Electric Company, Boston, Mass., claims that the motor-generator has an advantage over the dynamotor, in that the primary and secondary circuits of the motor-generator may be more effectively insulated from each other than can the windings of the dynamotor.

The motor-generator form of machine is flexible in its adaptation to engineering conditions. The voltage of the secondary may be regulated by a field rheostat; and if the fields of the generator are separately excited from the motor circuit, the voltage of the generator may vary from zero to the full potential of the machine; the current output and stability of voltage being retained throughout the entire range.

The machine in the accompanying illustration is made with two bearings, the intermediate bearings being eliminated. The motor and generator cores are mounted on a common shaft, which is continuous. The speeds are low, and the shafts quite heavy, so that there is no vibration nor tendency of the shafts to spring. The output of the machines ranges from one-quarter kilowatt to four and one-quarter kilowatts, and they may be wound to any direct-current circuit, and the secondary wound to give any voltage from 20 to 500.

The manufacturer of this apparatus is prepared to supply machines of the same range and outputs of the two-bearing construction, but of the open type. There is no particular preference in favor of either type, although possibly the open type is a little more accessible.

TWO-BEARING MOTOR-GENERATOR SET.

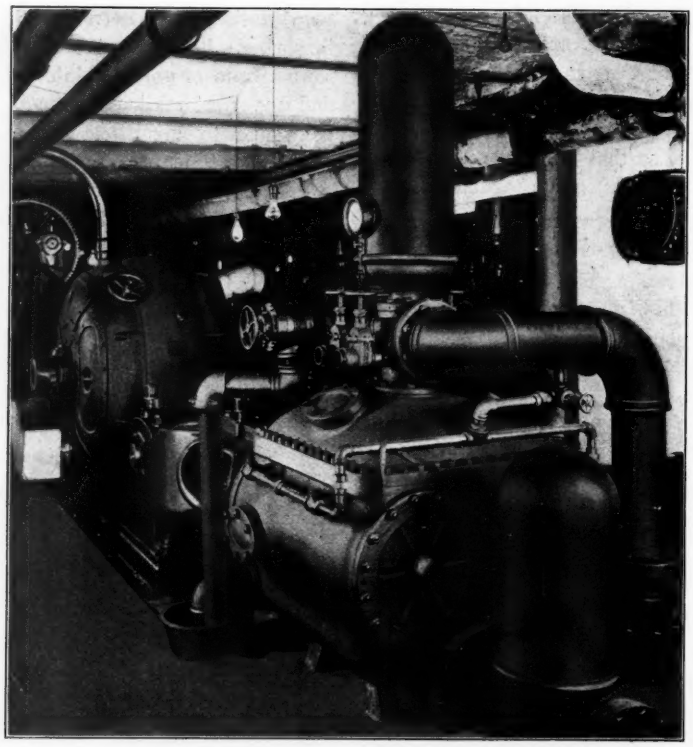
While these sets have been intended primarily for charging batteries, they have been found useful in other lines of work, particularly in telegraphic work for operating main and local circuits.

The Erie Railroad Contemplating Telephone Equipment.

The Erie Railroad has asked for estimates for stringing telephone wires along its line between Cleveland and New York. The company has been figuring on telephone equipment for some time. The line, if constructed, will be built on telegraph poles. The Erie line has a telephone service at present between Cleveland and the offices at Galion.

Fire Protection of the Marshall Field Department Store, Chicago.

The value of private fire apparatus for the protection of individual buildings and adjoining property was thoroughly demonstrated in the Baltimore and Toronto fires, and, in fact, the Baltimore fire department admits that many buildings on the immediate margin of the devastated tract were saved only by the effective work of private apparatus. These buildings were supplied with either stand-pipes or pumps connected with wet-pipe interior sprinklers and dry-pipe sprinklers for protection from outside fires, storage tanks holding from 1,500 to 15,000 gallons being placed on the roofs. Besides saving the buildings in which they were located these equipments stopped the advance of the fire, and undoubtedly many more buildings would have been destroyed in the absence of their efficient service. The buildings and contents protected by private apparatus in Baltimore were valued at five million dollars, and at Toronto the saving due to private protection was similar in extent.



MOTOR-DRIVEN HIGH-PRESSURE FIRE PUMPS.

The fact that such apparatus is on the ground, in position and ready for action averts the destruction of much property by both fire and water. A fire is usually well under way before the city fire companies can arrive, arrange their hose lines and make necessary couplings and connections. A drenching of the entire building is then often required, while a comparatively small amount of water would have put out the fire in the first place.

Fire insurance companies have recognized the decrease of fire risk in property containing private protection, and, consequently, are able to reduce premiums by such a percentage that the property owner is in a short time fully recompensed for the cost of the installation. The disastrous conflagrations of the past year have stimulated interest in the development of fire apparatus and a very extended adoption of private equipment is to be expected.

A recent installation of considerable interest is shown in the accompanying illustration. It is located in one of the largest buildings of its class in the world, Marshall Field's immense department store, occupying an entire block in the busiest section of Chicago.

The outfit consists of a Laidlaw-Dunn-Gordon duplex Underwriter pump connected by single-reduction gearing to a water-proof electric motor. The pump cylinders are eight inches in diameter by twelve inches stroke, having a theoretical capacity of 700 gallons per minute at 600 revolutions per minute, against 140 pounds water pressure. The illustration gives a good general idea of the pump, showing the special attachments and the large pressure and vacuum chambers required by the Underwriters' specifications. The pump is thoroughly rust-proof in all moving or wearing parts, ensuring prompt and smooth running when occasion arises.

The motor which was furnished by the Chicago Edison Company is shunt wound for 220 revolutions per minute at 230 volts and is enclosed, all connections being carried through pipes screwed into the frame, so that the device may be flooded without affecting its action. The fields and armature coils are cooled by fans on the armature shaft, the ventilator intake and outlet being visible in the photograph. This combination has been designed to ensure reliability and certainty of action under all conditions.

One of the important considerations affecting the selection of a device of this sort is the readiness with which electric power can be obtained and utilized; there being hardly a building where a reliable supply of electric current can not be cheaply and easily obtained. There is, further, no stand-by or maintenance expense as with steam apparatus.

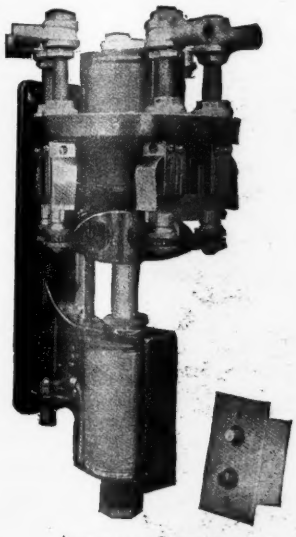
Steel Towers for Canadian Transmission Line.

The Canada Foundry Company, Toronto, is building for the Toronto & Niagara Power Company 2,800 steel towers. These will be used for the eighty-mile transmission line from Niagara Falls to Toronto. The towers of galvanized-steel angle-iron will be spaced at intervals of 400 feet. They will be forty-six feet high and fourteen by twelve feet at the base. The length will remain fourteen feet throughout, while the width will gradually diminish to a point. Four insulators on steel pins will be carried by a tubular steel cross-bar, while the other two will be placed on standards at the apices of the converging edges. In this way the insulators will form an equilateral triangle of six-foot edge. The towers will be planted on cedar blocks six feet deep, concrete being used when necessary. Where the line will cross the Welland canal the towers will be made higher to permit the passage of ships. The insulators, which will be cemented to the pins, will be of brown glazed porcelain in three or four parts. They will be of fourteen inches height and diameter. The line will be operated at 60,000 volts with four three-phase circuits, two being carried on each side of the tower. The conductor will consist of six strands of No. 6 copper wire, on a hemp core. Lightning arresters will be placed at intervals and provided with knife-switches for disconnecting from the line.

A New Automatic Switch.

The General Incandescent Arc Light Company, New York city, has placed on the market a new form of automatic switch. This device is designed with the aim of doing away with any unnecessary complication of wiring, at the same time reducing the cost of installation by eliminating a portion of the circuit. The controlling of this switch may be effected from any remote position without entailing any expense other than the running of a set of small wires for its control.

Among the many applications to which the company claims this automatic switch may be adapted is in places where the circuit is to be opened and closed from a number of different points. For example, in the case of a motor driving a pump, the motor can be stopped either



AUTOMATIC SWITCH.

by operating a push-button manually or by a float in the tank. This switch is available also in an installation where the motor is to be stopped by a limit switch which cuts the motor out of circuit in the event of the device running to the limit of its travel. The switches may be made use of in showrooms, art galleries and similar installations where the lights are to be turned on from a number of different places in the room, in which case the automatic switch is installed in an iron-lined wooden cabinet in the wall, and the controlling push-button switches are located at various operating places around the room.

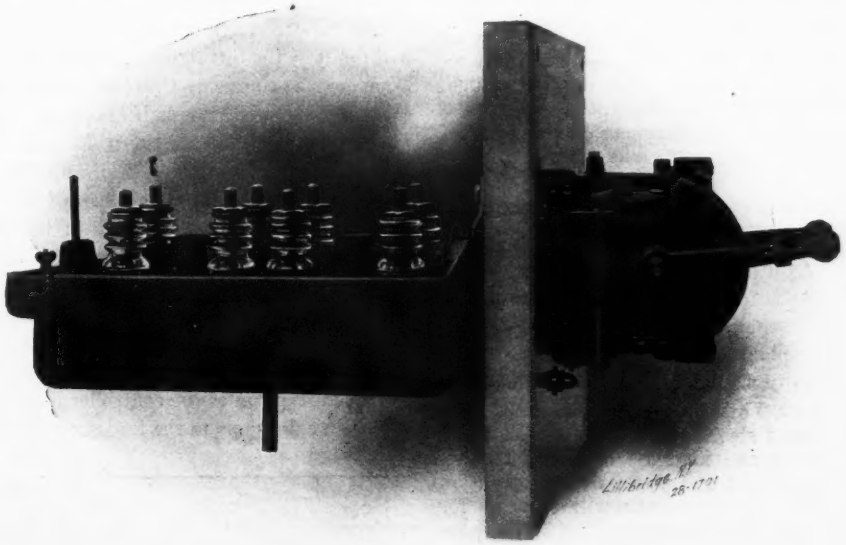
The *Four-Track News* for October is better, if possible, than usual. To name its good contributions would be to repeat the list of contents. The opening article is well illustrated and interestingly descriptive of the island of Ceylon.

New Forms of Oil Switches.

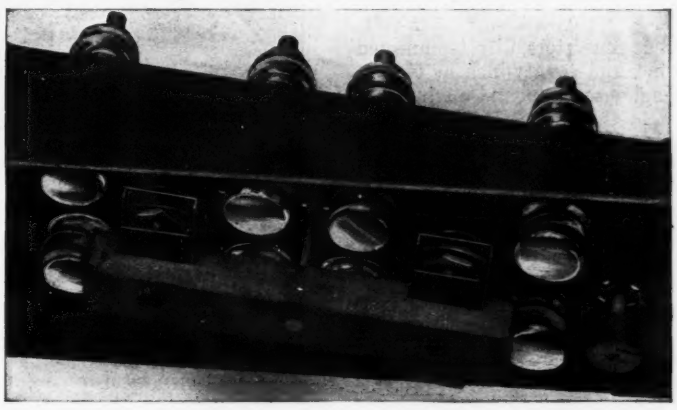
With the increasing success of high-voltage work, new forms of oil switches are constantly being brought out. In this field, the oil switch has given more or less satisfaction, although there is considerable prejudice one way or the other in favor of a horizontal or vertical break. The accompanying illustrations show the two-pole double-throw switch with automatic overload attachment, designated as form M, which has been placed upon the market by the Stanley Electric Manufacturing Company, Pittsfield, Mass.

This type of oil switch operates with a horizontal break. The contacts are located near the surface of the oil, and the arc, when drawn, is carried upward by the generated gases, increasing in length, and breaking just below the surface of the oil.

The switch is furnished complete with oil and tank. The breaking distance corresponds to the standard practice of the "S. K. C." system with lower voltages. For the higher voltages, however, the breaking distance is increased by multiplying the number of breaks, thus distributing the arc. Both fixed and moving contacts are disc-shaped, with rounding edges, and are interchangeable. When the switch is opened, arcing takes place between the rounded edges, rather than from the flat portions which form the contact surfaces. By thus providing arcing points, good contact surfaces are maintained at all times. From the back of each disc extends a threaded projection, which, in the case of the fixed contacts, screws directly into the ends of hollow studs. In the moving contacts, however, two nuts secure each to a connection strip. This construction facilitates removal, and the expense of replacing the discs is trifling. The rounded edges, after long use, become damaged by the arc, and perfect edges can be brought into play by giving the discs a partial turn. As the discs



NEW FORM OF HORIZONTAL BREAK, TWO-POLE, DOUBLE-THROW OIL SWITCH.



CONTACT BUTTONS, OIL SWITCH.

may be turned to six or seven different points before requiring renewal, the life of the form M switch is considerable.

The fixed contact discs are held against the lower ends of the insulators by hollow studs, into which they screw. The lead wires are soldered into the top of these studs, ensuring good connection. By means of ball joints, the moving contact discs are mounted upon the carriers, which are rigidly attached to the driving rod. These discs are self-aligning in regard to the fixed discs, against which, when the switch is closed, they are pressed by strong coil springs, eliminating all possibility of poor surface contact.

The Power Plant of the Louisiana Purchase Exposition for Sale.

At the close of the World's Fair, St. Louis, Mo., an unusual opportunity will be presented for purchasing high-grade power-plant equipment.

Westinghouse Church Kerr & Company, of New York city, have announced that the main steam and electric service plant designed and installed by them for furnishing light and power to the exposition buildings and grounds will then be for sale, either in its entirety, or, if the purchaser so desires, in its component parts.

The plant consists essentially of four 3,500-horse-power Westinghouse vertical cross-compound steam engines, thirty-eight-inch by seventy-six-inch by fifty-four-inch, running at eighty-five revolutions per minute and driving two 2,000-kilowatt alternating-current Westinghouse, and two 2,000-kilowatt alternating-current General Electric generators. The generators are three-phase, 6,000-volt, twenty-five-cycle, revolving-field type, and are located between the engine frames. The exciting current is furnished by three Westinghouse, eighty-kilowatt, 125-volt, direct-current generators, direct-connected to twelve-inch and twenty-inch by twelve-inch Westinghouse compound engines.

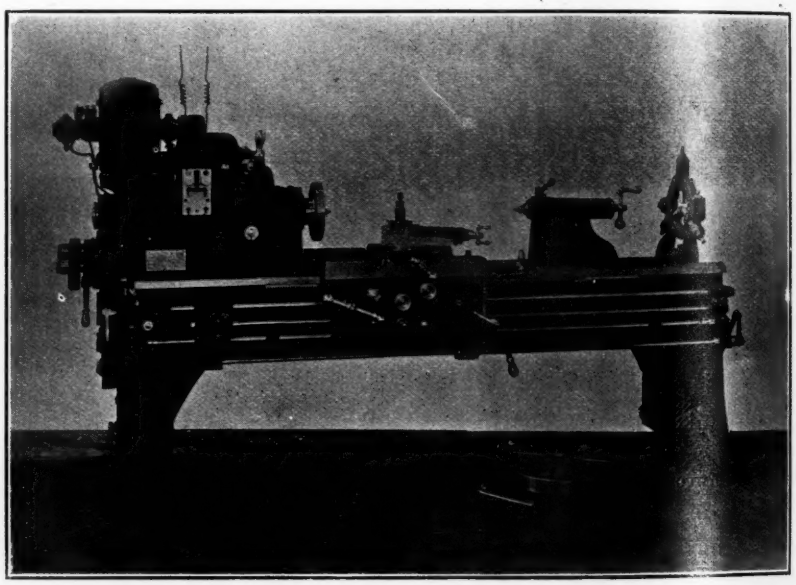
Adjacent to the engines are two forty-inch Worthington elevated jet condensers. Water is circulated by three twenty-four-inch Worthington turbine pumps, each delivering 18,000 gallons per minute, connected to eighteen-inch Westinghouse compound engines. There are also sixteen 120-inch Seymour disc fans, operated by an eighteen-inch Westinghouse compound engine, and two horizontal and one vertical Worthington dry vacuum pumps.

The service switchboard is located in a gallery at the west end of the Machinery Building.

The boiler plant with its accessories consists of sixteen 400-horse-power Babcock & Wilcox water-tube boilers, equipped with Roney mechanical stokers. There are two mechanical draught plants, each stack being connected with two fourteen-foot fans operated by direct-connected thirteen-inch by fourteen-inch Chandler & Taylor engines. The boilers are fed by one fourteen-inch by ten-inch by eighteen-inch "Admiralty," and two nine-inch and sixteen-inch by seven and one-half-inch by fifteen-inch Worthington pumps. The water is first passed through two No. 14½ Cochrane feed water heaters. A Holly gravity return system returns the water of condensation to the boilers.

The "Ideal" Motor-Driven Engine Lathe.

The "Ideal" engine lathe shown herewith, built by the Springfield Machine Tool Company, Springfield, Ohio, is equipped with a one and one-half horse-power motor made by the Northern Electrical Manufacturing Company, Madison, Wis. The motor has a normal speed of 600 revolutions per minute, capable of being increased to 1,200. A Cutler-Hammer controller regulates the speed of the lathe. This controller is bolted to the inner side of the rear leg of the lathe, and, while easily accessible, is thoroughly protected. The operating rod of the controller is supported in extensions to the lead screw box.



"IDEAL" MOTOR-DRIVEN ENGINE LATHE.

A handle at the right-hand side of the carriage operates the controller rod by means of mitre gears. The lathe has been especially designed for this motor connection, the headstock being cast with projections for carrying the motor and bearings for the extra shaft. A pinion on the motor shaft engages a gear on the extra shaft which is mounted directly over the lathe spindle. A pair of gears, which may be slipped into mesh with either of the gears which takes the place of the usual cone pulley, is placed on this shaft. In connection with the back gears which are thrown in and out by means of a pair of friction clutches, four mechanical changes of speed are obtained and these, with the hundred per cent speed variation of the motor, provide a wide range.

Cleaning Ships' Bottoms by Electricity.

It has been suggested that the growth of vegetation and animal matter and oxidation of the plates on the bottom of ships may be prevented by the use of electricity. For this process the ship's plate will be made the negative pole and an insulated copper piece the positive pole of a cell through which the current from the ship's generators will be passed. In the reaction taking place the hydrogen liberated from the water will prevent oxidation, while the resulting process will kill the animal and vegetable matter. The working cost, however, is very expensive and it will be necessary to reduce it markedly before the process can be financially feasible.

The Missouri Pacific Shops at Sedalia.

The Missouri Pacific Railway is building large repair shops at East Sedalia, Mo. Grading was commenced on May 10, 1904. The power-house equipment, contracts for which have not been let, will consist of five water-tube boilers of 250 horse-power each and Corliss compound non-condensing engines, working under 150 pounds pressure. The machinery will be operated by direct-current motors with a pressure of 245 volts at the switchboard. There will be three 200 and one seventy-five-kilowatt generators, a total power equipment of 675 kilowatts—about 1,000 horse-power.

Anniversary of the Roentgen Discovery.

A congress will meet in Berlin on April 30, 1905, to discuss the Rœntgen method. This will be the tenth anniversary of the publication of the discovery by Professor Rœntgen, who will be the guest of honor of the congress.

CURRENT ELECTRICAL NEWS

DOMESTIC AND EXPORT.

NEW RECEIVER FOR THE LAKE SUPERIOR CORPORATION—President D. C. Warren, of the Lake Superior Corporation, has been appointed receiver of the property of the Michigan Lake Superior Company. He takes the place of Benjamin F. Fackenthal, of Pennsylvania, who has retired. All of the properties are gradually being brought under one management, which will decrease the expense and ensure greater profits.

FRENCH GOVERNMENT TO SET UP WIRELESS STATION—The French government is about to install a wireless telegraph station on an island off the westernmost part of France. This will be used to communicate with incoming and outgoing transatlantic steamships. The war department is also extending the use of wireless telegraphy. Experiments at the Eiffel tower recently permitted the army officials at Paris to carry on wireless communication with Dijon, 200 miles distant.

GAS AND ELECTRIC COMPANY SOLD—The Luzerne County Gas Company and the Wyoming Valley Electric Light Company have been sold to Philadelphia and New York capitalists. The price paid is $50 per share for the gas stock, and $20 for the electric light stock. The new company will have a capital stock of $1,500,000 and an authorized bond issue of $3,000,000. The plants of both the gas and electric companies will be extended and other improvements made which will cost about half a million dollars.

MINING COMPANY TO INSTALL ELECTRIC PLANT—The Calumet & Hecla Mining Company is, it is announced, planning to install a large electric plant at Lake Linden, Mich. From this plant it will distribute power throughout its mills at Lake Linden and its mines at Calumet, displacing many smaller stationary engines now in use. The large hoisting engines at the shafts will not be disturbed. It is expected, however, that in the future electrical machinery will be devised to take the place of the present equipment.

THE NEW HAVEN RAILROAD FINDS ELECTRICITY IMPRACTICABLE—It is reported that the New York, New Haven & Hartford Railroad Company has dismantled its third-rail line between Nantasket Junction and Braintree, and will not operate its suburban lines by electricity for the present. The claim is made that the present appliances are not suitable for the existing conditions on this line, and it is probable that some time will elapse before a further attempt is made towards electrification. This branch was equipped with the third rail as an experiment some years ago.

NEW MEXICAN ELECTRIC LINE—M. D. Watson and J. R. Bickerdike, members of a Chicago company recently organized to work the Rosa Amarilla copper mines in the western part of the state of Guadalajara, Mexico, have applied to the federal government for a concession for a projected electric railway to connect the mines and the Pacific port of Navidad. The road will be about forty miles in length, and will cost more than a million dollars. Current to operate the road and the machinery at the mines will be secured from power plants to be erected on two rivers in that section of the state.

TO INSTALL TELEPHONES ON TROLLEY CARS—Contracts have been let by the Auburn & Syracuse Electric Railroad Company whereby a telephone system will be installed, which will enable cars at any point on the line to communicate directly with headquarters at Auburn or Syracuse, or any station along the line. The company already has a telephone line between Syracuse and Auburn, with two wires. One wire is used for the transmission of office business, and the other will be employed for operating cars. Considerable difficulty was experienced last winter locating cars along the line which were in trouble, because the telephone system was not in use. Each car operated on the line will have a portable telephone. By the use of a portable "jack," connections can be made with the telephone wire at any point, and the conductors can telephone to any station. Cars will be despatched and receive orders by this system also.

THE REPORT ON THE TELEPHONE SYSTEMS OF PENNSYLVANIA FOR 1903—The annual report compiled by the department of internal affairs of the state of Pennsylvania gives a summary of the financial statements of eighty-seven telephone companies, as well as a number of telegraph companies. Of this number, nine companies are identified with the Bell interests, and seventy-eight are independent companies. The total number of independent telephones reported in use by seventy-two companies was 62,077. The total reported investment for these companies was $19,839,045, or an average investment of $320 per telephone. The total investment recorded for seventy-six companies was $20,533,233, while the gross income from these seventy-six systems was $1,352,978.

CANADIAN ELECTRIC PLANT UNDER CONSTRUCTION—The Quebec Electric Company is starting work on the installation of its plant, at St. Anne and Seven Falls. The technical work of the engineers employed by the company has been completed, the plans are now approved, and the work of organization arranged. The construction of the dams necessary, and the foundation work in connection with the power-houses, at each of the falls, will be commenced with the least possible delay. The engineers employed by the company to report and survey upon the water-power possibilities of the St. Anne and Seven Falls properties are E. Gauvin, civil engineer of the provincial crown lands department, and Beaudry Leman, chief engineer and general manager of the Shawinigan Falls Water-Power Company. Water will be taken from Seven Falls at 374 feet. The two falls will develop, at low water, between 22,000 and 25,000 horse-power.

IMPORTANT TROLLEY DEAL—The Pittsburg, McKeesport & Connellsville Trolley Company is in full possession of the Pittsburg, McKeesport & Greensburg line, the deal having been closed last week. The purchase price is said to have been $2,000,000. This gives the former company a very extensive system throughout the state of Pennsylvania. Starting from Trafford City, where connection is made with the Pittsburg Street Railway Company, the line runs toward Irwin, where three miles of open space is being completed. From Irwin, the line is in operation to Manor, Penn, Jeannette, Greensburg, Mount Pleasant, Scottdale, Connellsville, Uniontown, Fairchance and smaller towns in the coke region. When a gap between Irwin and Trafford City is completed, passengers can ride from Pittsburg to the end of the line, a distance of seventy miles. It is expected that express service will be undertaken from Uniontown to Pittsburg.

MEXICAN ELECTRICAL NOTES—It is announced that the old electric plant at Tampico, Mexico, will be enlarged and placed under the management of C. C. Freston. A new dynamo capable of supplying 4,000 lights, which with the existing equipment assures a total supply of nearly 10,000 sixteen-candle-power lamps, will be installed. New boilers, pumps and heaters are also being contracted for. Contracts have been made for rewiring the streets and extending the lines. A newly organized company has taken charge of the electric light plant at Mazatlan, western Mexico. This company will shortly be in the market for supplies. Jose H. Rico, Mazatlan, state of Sinaloa, Mexico, is prominently interested in the company. The Compania Campechana de Electricidad y Fuerza, city of Campecha, state of Campecha, Mexico, which was recently organized for the purpose of constructing and operating an electric lighting and power system, is about to let contracts for equipment. Alberto Terrazas is president of the company; W. E. Hermann is vice-president, and H. H. Hinkle is general manager. It is stated that orders have been placed for

the necessary machinery for a hydroelectric power and lighting plant at Colima. It is expected that the work of installation will be commenced very soon.

PLANS FOR NEW EDISON POWER STATION—Preliminary plans have been filed for a new fireproof power station to be built for the New York Edison company. This building will be three and one-half stories high, and will be constructed of granite and brick. It will have a frontage of 197.5 feet, and a depth of 347.2 feet. Its cost is estimated at $1,200,000.

CONSOLIDATION OF TRACTION AND LIGHTING COMPANIES—The Alton Light and Traction Company has been consolidated with the St. Louis & Granite City Railways under the name of the Alton, Granite City & St. Louis Traction Company. The Alton Gas and Electric Company, with a capital of $500,000, will take over the gas and electric plants, and the hot-water heating system of the street railway. The officers of the new gas and electric company are F. E. Allen, president; J. F. Porter, vice-president; George G. Kuhn, secretary, and O. S. Stowell, treasurer.

TO REORGANIZE ST. LOUIS TRACTION COMPANIES—A plan has been perfected to reorganize the finances of the St. Louis Transit Company and the United Railways, of St. Louis, and to reduce the capitalization by $33,000,000. The transit stock is to be exchanged for the common stock of the United Railways Company, in the form of voting trust certificates, in the proportion of two shares of the United Railways common for five shares of transit stock. The plan has been approved by the boards of both companies. This scheme will provide working capital for the United Railways Company, and a reserve of $7,000,000 preferred stock to meet future requirements.

MERGER OF TELEPHONE LINES—The Citizens' Telephone Company, of Newcastle, Pa.; the Union Telephone and Telegraph Company, and the Mercer County Telephone Company are included in a merger of independent companies of western Pennsylvania and western New York under the name of the Erie Telephone Company. The consolidated company, it is reported, includes more than twenty exchanges. Another important merger of independent telephone companies was undertaken in Kansas City last week. The stock and lines of the Western Independent Telephone Company were transferred to the Kansas City Home Telephone Company, and the affairs of the former company are now being managed directly by the latter.

NEW WASHINGTON POWER PLANT ABOUT COMPLETED—The work of construction on the electric plant at the falls of the Kalama river, Kalama, Wash., is about completed. A flume 1,000 feet long, six feet deep and twelve feet wide has been built. This flume has a fall of forty-five feet, and can be kept full of water even in the dryest weather. A water-wheel is in place, and a 150-horse-power dynamo has been installed. This is sufficient for present use, but the plant is so arranged that another water-wheel can be put in at any time with but little extra cost. It is estimated that the water power is sufficient to generate 1,500 horse-power, when it is all utilized. The line is about ready to convey current to Kalama, and the work of placing circuits in the houses is well under way.

THE EXTENSIVE WORK OF THE CHESAPEAKE & POTOMAC TELEPHONE COMPANY—The Chesapeake & Potomac Telephone Company will reconstruct its former central exchange building on St. Paul street and Bank lane, Baltimore, Md. For a time the company contemplated getting a new site, and several pieces of property were under consideration, but it has been decided to go back to the old location. The company has practically completed another new branch exchange which will relieve the Mount Vernon exchange of some of the pressure caused by throwing into that exchange the business district after the destruction of the St. Paul exchange. The new exchange will take in the whole eastern end of Baltimore, from the harbor frontage to the northern limits, and will be ready for operation by January 1, with a capacity for 3,500 lines This will make the sixth exchange inside the city, and the seventh with the rebuilding of the St. Paul exchange. These exchanges aggregate a capacity of 20,000 lines, or about 30,000 telephones.

PERSONAL MENTION.

MR. H. J. FOALE has been appointed signal engineer of the Wabash Railroad.

MR. J. B. SMITH has been appointed to the newly created office of the city electrician, at Jackson, Cal.

MR. E. W. DAY has been appointed to the assistant superintendency of telegraphy of the Baltimore & Ohio Railroad.

MR. JOHN F. WALLACE, chief engineer of the Panama canal, has returned after a thorough inspection of the route of the canal.

MR. W. C. SMITH, recently manager of the Pennsylvania & Mahoning Valley Railway Company, has resigned and has accepted a position in Pittsburg.

MR. O. H. CLARKE, graduate of the Polytechnic Institute of Brooklyn, is now a member of the sales department of the Crocker-Wheeler Company, Ampere, N. J.

MR. W. G. RAYMOND, of the Rensselaer Polytechnic Institute, has been appointed head of the engineering department of the Iowa State University at Ames, Iowa.

PROFESSOR ROBERT SIBLEY, of the department of electrical engineering at the University of Montana, was recently married to Miss Ada Catherine Stone, at Berkeley, Cal.

MR. FRANK HEDLEY has been appointed general manager of the Interborough Rapid Transit Company, the office of general superintendent, which he formerly held, being abolished.

MR. I. T. DYER has resigned his position as superintendent of telegraphy of the Chicago, Burlington & Iowa lines, west of the Missouri river, and will engage in other business at Los Angeles, Cal.

MR. W. A. BLANCK, having left the Arnold Electric Power Station Company, of Chicago, is now associated with the Chicago & Milwaukee Electric Railroad Company as electrical engineer, with headquarters at Highwood, Ill.

MR. A. A. THRESHER, of the Thresher Electric Company, Dayton, Ohio, spent several days in New York last week taking part in the launching of the battleship Connecticut. His company supplied a part of the electrical apparatus used on this boat.

MR. C. B. ROULET, the special representative of the Osburn Flexible Conduit Company, New York, resigned his position on October 1 to assume charge of the inspection department of the Texas Fire Prevention Association, at Dallas, Tex.

MR. A. J. BEMIS, who has been in charge of the Plymouth Electric Road and Mayflower Grove, has been appointed to the position of manager of the Cape Breton Electric Company and the Sydney & Glace Bay Electric Company, of Cape Breton, Nova Scotia.

MR. NEWCOMB CARLTON, vice-president of the Buffalo Bell Telephone Company, and formerly director of works and director-general of the Pan-American Exposition, tendered his resignation at a recent meeting of the directors of the company. Mr. Thomas T. Ramsdell was elected to fill the vacancy.

MR. EUGENE G. ELLIS, county manager of the Sunset Telephone Company, has been promoted to be district manager of a newly formed district, embracing Alameda, Contra Costa, San Mateo, Santa Cruz, Santa Clara, San Benito, San Luis Obispo and Monterey counties, and a part of Santa Barbara, with headquarters in Oakland, Cal.

MR. A. W. BRADY has been elected president of the Indiana Union Traction Company and the Indianapolis Northern Traction Company, succeeding Mr. George F. McCulloch who resigned last week. Mr. Brady has been vice-president and general consul for both companies. Mr. McCulloch was elected president of the board of directors of the companies.

MR. J. E. ALDRED, of Boston; Mr James Ross, of Montreal, and Mr. Frederic Nicholls, of Toronto, some time ago jointly contributed a sum of money to enable Mr. Ralph D. Mershon to take up certain high-voltage experimental work, the results of which are to be made public in a paper by him. The preparations for this work, which will be done at Niagara Falls, N. Y., are about completed, and the work itself will soon be under way. It is pro-

ed to make measurements on an experimental line up to at least 0,000 volts, and possibly as high as 200,000 volts.

MR. FREDERICK G. SYKES, who has been electrical engi- er for several years with the Schenectady Railway Company, signed on October 1 to become general superintendent of the Port- d General Electric Company, Portland, Ore. Mr. Sykes installed e Sydney tramway system in Sydney, Australia, and previously s operating superintendent of the Brooklyn Edison Company.

MR. GEORGE S. HALEY, Rutland, Vt., has been appointed by esident Davis, of the National Electric Light Association, as a mmittee to report on the subject of methods in use for the thaw- of frozen water pipes by electricity. It is understood that Mr. aley has the work well under way, with a view of publishing sults before the freezing weather sets in. An article on this bject was contributed to the "Wrinkle" department by Mr. Haley the Boston convention.

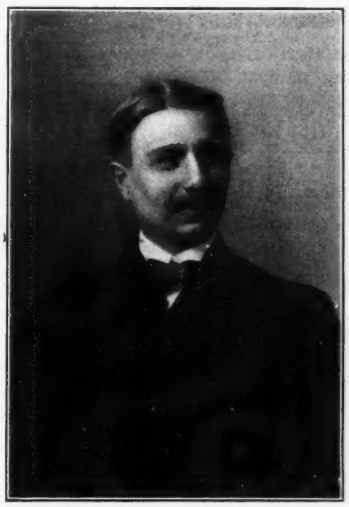
MR. THOMAS FARMER, who has been successively superin- ndent of motor power of the Detroit United Railway Company d of the G. C. Kuhlman Car Company, has opened an engi- ering office in the Electric Building, Cleveland. Mr. Farmer's tention is to specialize on car engineering and inspection. As perintendent of motive power at the car shops of the Detroit ited Railways for nine years, he gained valuable experience the handling of rolling stock which fits him well for his new ecialty.

MR. E. E. F. CREIGHTON has been appointed assistant pro- sor of electrical engineering in Union College, Schenectady, Y. Mr. Creighton is a graduate of Leland Stanford University, lifornia, class of 1895. He received the degree of engineer upon duation, and for the three years following studied under Dr. A. C. Perrine. After concluding his studies under Dr. Perrine, rofessor Creighton went abroad and spent two years studying arious branches of science at the Sorbonne, in Paris, France. At e expiration of his studies, he was given the degree of electrical gineer, and he returned to Leland Stanford University, where remained a year as professor of engineering. In 1901, he ac- pted a position in the experimental department of the Stanley ectric Manufacturing Company, Pittsfield, Mass. Quite recently was in the service of the General Electric Company, at Schenec- dy, as a consulting engineer at the local works.

MR. THEODORE FEILDEN, editor-in-chief of the *Electrical agazine*, London, and managing editor of the Electrical Publish- g Company, Limited, has been spending a considerable time in e United States, looking into the characteristics of the various dustrial centres. Mr. Feilden came to the United States as a legate to the International Electrical Congress, and after his uties were finished at St. Louis he made trips to various other arts of the country. On Saturday, October 1, Mr. Feilden was visitor at the White House, and held an extended interview with resident Roosevelt. Mr. Feilden was greatly impressed with e intense interest manifested by the President in scientific ork, and by the thorough knowledge of which he was pos- ssed with reference to this subject. Mr. Feilden has been a well- nown writer on British commercial subjects for a number of years. n important series of articles appeared in the London *Daily Mail*, nder the title "Is British Trade Falling?" arousing widespread nterest in trade and industrial circles in Great Britain and America.

MR. CHARLES S. BUELL, mechanical engineer, until recently epresenting the Westinghouse Machine Company in Chicago, Ill., as entered the employ of the Allis-Chalmers Company as salesman nd engineer in the power department. Other additions to the ersonnel of the Allis-Chalmers Company are as follows: John F. Burke, who will engage in the sale of Corliss engines, electrical pparatus and crushing and cement machinery; Wilbur M. Ruth, alesman and engineer at the Pittsburg office; M. C. Miller, who ccepts a position in the alternating-current division of the elec- rical department; Charles F. Adae, who joins the selling force at he New York office; S. H. Sharpsteen, salesman in the New York ffice; G. Fred Collins, special representative at the Chicago office; R. L. Richardson, who becomes a member of the Pittsburg selling taff; John V. Redfield, who joins the sales staff at the Chicago office; James Ashworth, salesman in the pumping engine department; Otto Clyde Ross, as engineer and salesman; W. M. S. Miller, at the Chicago office.

MR. JAMES B. HOGE, the new president of the National Independent Telephone Association of America, was born near Flushing, Belmont County, Ohio, December 20, 1866. His early life was spent upon his father's farm, he securing his early education in the country school near Flushing. At the age of sixteen he took up the study of bookkeeping, telegraph operating and other railroad work, and entered the service of the Western Union Telegraph Company at Flushing. When he was eighteen, he accepted a position as night telegraph operator for the Cleveland, Lorain & Wheeling Railroad at Bridgeport, Ohio. During the next two years he occupied various positions with this railroad and its allied interests. In 1888 he was transferred to Lorain as the chief clerk for the Cleveland, Lorain & Wheeling and Nickel Plate railroads. He held this position for nearly three years, when he retired from the railroad company and organized the Lorain Savings and Banking Company, of which he became secretary and treasurer. In 1894 he was elected secretary of the Lorain chamber of commerce. During this year arrangements were made for the Johnson Steel Company to move its works from Johnstown, Pa., to Lorain. The chamber of commerce negotiated a number of improvements for the city, and among other things undertaken was the securing of a telephone company. While secretary of the Lorain Savings and Banking Company, Mr. Hoge became connected with the Everett-Moore syndicate. In 1898 he was made secretary of the United States Telephone Company, resigning his position in the bank and moving to Cleveland. He is still secretary of the United States Telephone Company, and also vice-president of the Federal Telephone Company. Mr. Hoge organized the Citizens' Gas and Electric Company, of Lorain and Elyria, consolidating the electric light, gas and steam-heating interests of these cities into one organization, and later selling the interests to the Union Natural Gas Corporation, of Pittsburg. Mr. Hoge is a member of the Union Club, of Cleveland. In 1891 he was married to Miss Anna Wallace, of Lorain.



MR. JAMES B. HOGE.

OBITUARY NOTICES.

MR. W. C. ROBINSON, chief inspector of the Southern Bell company, died on the evening of September 26, at his residence in Atlanta, Ga. Mr. Robinson was born in Orange, N. J., forty-eight years ago. About twenty years ago he went to Atlanta to accept a position with the Southern Bell Telephone Company, for whom he worked until his death, rising to the position of chief inspector through efficient and faithful service.

MR. CLARENCE M. DALLY, an electrical engineer, died on October 2, at his home in East Orange, N. J. It is understood that for seven years Mr. Dally was a sufferer from a cancerous affliction which was primarily due to exposure to chemicals and the action of X-rays during continuous experimental study. At one time Mr. Dally was one of the chief assistants in the experimental laboratory of Mr. Thomas A. Edison. Mr. Dally was born in Woodbridge, N. J., thirty-nine years ago, and served five years in the United States navy as chief gunner on the Enterprise. He had been connected with Mr. Edison for the past sixteen years.

ELECTRIC LIGHTING.

STONE CITY, IOWA—H. F. Dearborn is interested in establishing an electric light plant.

MIDDLETOWN, ILL.—Steven Sturgis has purchased the electric plant from William Allison.

FORT WAYNE, IND.—Two 400-horse-power boilers will be installed in the electric light plant.

OMAHA, NEB.—The Omaha Electric Light and Power Company will install a 2,000-horse-power steam turbine.

DILLSBORO, IND.—William E. Swarthout is back of a movement to build an electric lighting plant at Dillsboro.

INDEPENDENCE, KAN.—An electric light franchise has been granted W. Nees. The city is to take ten lights at $725 a year.

EVELETH, MINN.—The Eveleth Electric Company is installing an additional 100-horse-power boiler in its plant at this place.

TROY, N. Y.—The property of the recently formed Lozier Light and Power Company has been sold to H. G. Runkle, of New York city.

DAYTON, TENN.—Thomas E. Stone has been awarded the contract to rebuild the electric light plant, which was recently destroyed by fire.

JOHNSTOWN, PA.—The directors of the new Dale Electric Light Company have awarded the contract for the building to John D. Strayer.

BELLOWS FALLS, VT.—The Fall Mountain Electric Light and Power Company has placed its plant in operation and is now lighting the city streets.

CAIRO, GA.—The city council, of Cairo, has ordered an election for October 20 to determine the question of waterworks and electric lights for Cairo.

KAUKAUNA, WIS.—The Kaukauna Electric Light Company has sold its property in this city to a new company of Milwaukee capitalists, who have taken possession.

GRINNELL, IOWA—O. K. Cole, of Cincinnati, Ohio, has purchased a controlling interest in the electric lighting plant here. He is making extensive improvements.

CINCINNATI, OHIO—By virtue of a resolution passed by the council, Bond Hill will have its streets lighted with electricity after January 1, 1905, instead of with naphtha, as at present.

ARKANSAS CITY, KAN.—The plant of the Arkansas City Gas and Electric Light Company has been totally destroyed by fire. The plant was valued at $45,000. The insurance was $3,300. It will be rebuilt at once.

CANAL DOVER, OHIO—The council has renewed a contract for a term of five years with the A. Beyer & Leiser Electric Company, of New Philadelphia, for lighting the city. The contract price is $54.44 each arc light.

BALTIMORE, MD.—The contract for lighting the city has been awarded by the board of awards to the American Lighting Company for a period of three years from March 1, 1905, at a total saving to the municipality of $79,594.50.

STAFFORD, ONT.—A by-law authorizing the issuing of debentures to the amount of $19,300 for the purpose of purchasing the electric lighting plant by the town of Seaforth, was voted recently and carried by a majority of three.

FORDYCE, ARK.—The Fordyce & Kingsland Interurban Lighting line has been completed, and is now in operation. It runs from Fordyce to Kingsland, a distance of eight miles, and is operated by the Fordyce Light and Water Company.

OAKLAND, CAL.—The Comstock Pumping Association, composed of thirty-one mining companies, has contracted with the Truckee River Electric Company for the erection of a new power plant on the Truckee river. The plant will cost $200,000.

BALTIMORE, MD.—The Susquehanna Light and Power Company reports that work will begin at once. The company has had a corps of surveyors at work for a year surveying between Octoraro, Md., and Fites Eddy, and has options on most of the land on t river front between those points. There are to be three pow plants erected.

REDDING, CAL.—Work has begun on the power plant to erected at Horse Shoe Bend, Battle Creek, and will be pushed forw as rapidly as possible. San Francisco capital is interested and it thought that the plant will be running before many months.

TALLADEGA, FLA.—The Talladega Electric and Power Co pany has been incorporated. Bonds of this company to the amou of $50,000 have been issued and taken by local people. The obj of the company is to develop water power at Jackson shoals, Choccolocco creek, and supply the city with electric lights.

UNION HILL, N. J.—The United Electric Light Company, New Jersey, has been awarded a contract by the council of Uni Hill at the rate of $85 a light a year, $15 a light less than t town had been paying, the company also to maintain without char the fire-alarm system and to allow a reduction of fifteen per cent the cost of light used in municipal buildings.

SAN FRANCISCO, CAL.—The Siskiyou Electric Power Co pany, through the local company, the Little Shasta Power Co pany, has completed the installation of its power line through Lit Shasta valley, thus adding fourteen miles to its distributing syst in Siskiyou County. The Siskiyou electric is now operating seven six miles of line, lighting six towns, and supplying power for gr mills, ice plants, sawmills, mines and pumps for irrigation.

BURLINGTON, VT.—A contract has been awarded by the Ch tenden Power Company, of Rutland, for the construction of a pow house to cost $125,000. It will be built at Mendon and will be us in connection with the reservoir which is being constructed Chittenden. The dam at the Chittenden reservoir is one of t largest in New England and was built at a cost of $1,000,000. T reservoir is located two miles east of Chittenden village and w contain 3,750,000,000 gallons of water, which, at that elevation, capable of supplying between 3,000 and 4,000 horse-power dail The water is conveyed to Mendon, where the power-house will located.

EDUCATIONAL NOTES.

THE FRANKLIN INSTITUTE, Philadelphia, has issued a pr gramme of lectures to be given during the year 1904-5. Amon these will be included lectures on "Radioactivity," the "Steam Tu bine," the "New York Subway," "Engineering Features of th Louisiana Purchase Exposition," and "Magnetite Arc and Mercur Arc Lamps."

THE WORCESTER POLYTECHNIC INSTITUTE—The Wo cester Polytechnic Institute has secured the services of Mr. H C. Walter, a graduate of 1900 and associate member of the American Institute of Electrical Engineers, as an instructor in electric engineering. Mr. C. D. Knight, of the class of 1903, has bee appointed an instructor, and Mr. F. J. Adams, class of 1904, graduate assistant of electrical engineering.

LEHIGH UNIVERSITY—Lehigh University has made the fo lowing additions to its engineering faculty: Professor Winte L. Wilson, formerly of Tulane University, has been appointed as sistant professor in civil engineering; Sherman M. Turrill and Robert W. Gay, of New York University, and Arthur W. Klein and Evart O. Eastwood, University of Virginia and Massachusetts Institute of Technology, instructors in civil engineering. The following instructors have also been appointed: Charles W. Brown department of Geology, Stanley S. Seyfert, electrical engineering and George C. Beck, chemistry.

THE STATE COLLEGE OF IOWA—The State College of Iowa has arranged a series of ten lectures to be delivered during the present college year by officials of various railway systems in Iowa. The first lecture was delivered by Judge J. C. Davis, chief attorney for Iowa, of the Chicago & Northwestern Railway, his subject being "The Relation of the Railways as Common Carriers to the State and Federal Governments." Other lectures will be on "Railway Accounting," "Tie and Timber Preservation," "Motive Power," "Relation of the Railways to the Producers," "Signal Engineering" and "Maintenance of Way."

ELECTRIC RAILWAYS.

INDIANAPOLIS, IND.—Notice has been given by the Evansville Eastern Electric Railway Company of an increase in its capital ck from $10,000 to $600,000.

SPRINGFIELD, OHIO—The county commissioners have granted G. H. Frey, Jr., an extension of time for one year on the franchise his proposed traction line to Clifton.

PORT CLINTON, OHIO—Work has been nearly completed on the electric railroad, and cars will soon be in operation. Grading Lakeside and Marblehead will then be started.

SOUTH McALESTER, I. T.—Work has been begun on the extension of the electric railroad from its present terminus to Wilton, a distance of nearly thirty miles from South McAlester.

WEST CHESTER, PA.—A tract of land in Willistown township has been purchased by the Philadelphia & West Chester Traction Company, on which will be erected a new power-house to cost 0,000.

PORT WORTH, TEX.—The Northern Texas Traction Company spend about $25,000 in improvements on the north side in track ing, as per the franchise granted by the city council of North rt Worth.

MORRISTOWN, N. J.—The Morris County Traction Company pushing the work of building the line from Dover to Rockaway ast as possible, and it is expected to have the line in operation November 1.

EVERETT, WASH.—A franchise has been granted by the county missioners to E. G. Kreuger for an electric railway from Index Mineral City. Machinery and material for the road are to be chased at once.

PORT EWEN, N. Y.—A New York syndicate has opened negotiations for the building and operation of an electric railway from ghtsburgh to Port Ewen, with a terminal at the intersection Riverside avenue.

SPARTANBURG, S. C.—In keeping with a meeting of the directors held in New York city on August 5, the stockholders of the rtanburg Railway, Gas and Electric Company have voted a d issue of $400,000.

EVANSVILLE, IND.—The C. C. Tennis Construction Company, Cincinnati, has been awarded the contract for the construction a new electric line between this city and Newburg, in Warrick nty, and work has been commenced.

NEW HOLLAND, PA.—It is expected that work will soon be mmenced on grading the Lancaster, Georgetown & Oxford trolley d. The road will pass through Georgetown, Green Tree, Nine nts, Bartville, Kirkwood, Union and Oxford.

OAKLAND, CAL.—The Stockton electric railroad is to be reconstructed as soon as the San Jose and Los Gatos interurban line completed. The Stockton road will be changed from a narrow standard gauge system and will be extended to Lodi.

CLEVELAND, OHIO—The Sandusky, Norwalk & Mansfield Traction line will be built at once. The line has been in contemplation a long time, and it is said that Sandusky capitalists have backed project to such an extent that it is absolutely assured.

CHICAGO, ILL.—The Chicago & Western Indiana Railroad has the contract for an electric power plant to furnish motive wer for its suburban service. The building will be one story high, 85 by 150 feet ground dimensions, and will cost $150,000, exclusive equipment.

LOUISVILLE, KY.—The Louisville & Southern Indiana Traction mpany has filed in the office of the county clerk, at Corydon, the n and profile of the New Albany & Corydon Rapid Transit Electric Railway, evidencing that it is the purpose to shortly begin the rk of constructing the road.

CINCINNATI, OHIO—The village council of Milford has awarded to the Cincinnati & Columbus Traction Company a franchise the use of the streets of that village for twenty-five years. This es the place of a franchise which recently expired, because no rk has been done on the construction of the line.

JOHNSTOWN, PA.—John Hartigan, president of the Mt. Pleasant Heat and Light Company, is the head of a company just organized to build a trolley line from Mt. Pleasant to Unity, Westmoreland County. Nine miles of the right of way have been secured. Several Pittsburg capitalists are interested in the venture.

LA GRANDE, ORE.—It is stated that the proposed electric railway for Union County will not only connect all the towns in the county, but will connect Wallowa County with Union County, and it is thought will ultimately be extended to Lewiston, and thus establish a railroad between the Hill and Harriman lines.

DANVILLE, PA.—An agreement has been reached between the Danville & Bloomsburg Street Railway Company and the Columbia & Montour Electric Railroad Company, whereby the first-named company is to use the tracks of the Columbia & Montour line from a point near Fishing creek to the court house in Bloomsburg.

HARTFORD, CT.—A new trolley line has been opened connecting Hartford with Springfield, Mass., by a route which runs on the west side of the Connecticut river. There has been for two years a line on the east side. The new line goes from here to Windsor and thence by way of Suffield, Agawan and Mittineague to Springfield.

EDGERTON, WIS.—The Southern Wisconsin Interurban Railway Company has filed an acceptance of a franchise to build its line through this city, granted by the council some months ago. The proposed line will run from Janesville to Madison *via* Milton Junction, Edgerton, Albion and Stoughton. Work of grading is to be commenced this fall.

PETERSBURG, MICH.—At a mass meeting it was voted to accept the terms of the Ohio & Michigan Traction Company in regard to the location of the power-house, car barns and repair and machine shops. A site of seventeen acres was provided for and a bonus of $5,000 raised. Work will be begun at once and the plant rushed to completion.

GOSHEN, IND.—Work on the new interurban line from Warsaw to Goshen, which is intended to go far toward completing the chain of electric railways from Benton Harbor to Cincinnati, has been begun. All the right of way has been secured. H. J. Heinz, of Pittsburg, is one of the capitalists interested and Indianapolis men are also in the company.

DOYLESTOWN, PA.—It is stated that a plan is under way to convert the abandoned Delaware & Atlantic Railway, in Montgomery and Chester counties, into an electric railway. The old road was eleven miles long, extending from a point west of Phœnixville to a point near French Creek. George F. P. Wanger is said to be back of the project.

PENSACOLA, FLA.—It is stated on good authority that an electric road will soon be constructed between this city and a point on Mobile Bay, from where connection will be had with Mobile by a line of fast steamers. It is said that work on the survey is going ahead rapidly, and that the chances are good for the completion of the road during the next few months.

SIOUX FALLS, S. D.—The city council has granted to a syndicate of Des Moines, Iowa, capitalists a franchise for the construction and operation of an electric street railway system in Sioux Falls. The syndicate is composed of S. C. Lee, A. H. Marshall, W. R. Marshall, J. R. Sheely and G. W. Rhine. It is expected that work on the electric street railway will commence in the course of the next few weeks.

NORRISTOWN, PA.—An extension of the proposed Souderton, Skippack & Fairview Electric Railway Company's route has been placed on record here. The proposed extension takes in a wide area, including part of the Perkiomen valley. The distance to be traversed is fourteen miles, nearly doubling the original length of the road. The system will connect with the trolley railways entering Norristown.

ARKANSAS CITY, KAN.—The directors of the Kansas-Oklahoma Interurban Railway have elected the following officers: W. C. Robinson, president; L. H. P. Northrup, president and general manager; C. A. Scruton, secretary and treasurer; S. P. Gould, auditor and assistant general manager, and C. L. Brown, attorney. The

other members of the board are: W. H. Somermeir, of Winfield, and A. J. Hunt, of this city. The executive committee is composed of L. H. P. Northrup, C. A. Scruton and S. P. Gould. The survey for the road has been completed. It will connect Arkansas City, Chilocoot, Gueda Springs and Winfield.

TOLEDO, OHIO—The Toledo Interurban Railway Company, with a capital stock of $100,000, has been incorporated at Columbus by C. V. Wagner, Edgar Daykin, W. M. Long, George W. Acker and P. S. Willis. According to the incorporation papers the road will extend from this city, northwesterly to state line, where it will connect with the Toledo & Ann Arbor road, giving a through service from Toledo to the Michigan city.

LIMA, OHIO—At a meeting of the owners and promoters of the Fort Wayne, Van Wert & Lima Traction Company, and the Ohio & Indiana Construction Company, which has charge of the building of the line, the following were elected officers of the Fort Wayne, Van Wert & Lima Traction Company: president, James Murdock, La Fayette; vice-president, J. D. Cable, Lima, Ohio; secretary and treasurer, J. D. S. Neely, Lima, Ohio.

GRAND RAPIDS, MICH.—E. M. Higgins, promoter of the Grand Rapids & Ionia Electric line, has filed a trust mortgage to the Empire Trust Company, of New York, for the purpose of securing bonds to the amount of one million dollars to be used in the construction of the road and power-house. It is announced that work will begin at once and that the grading will be completed in sixty days. The road will be completed by the first of May, 1905.

WHEELING, W. VA.—The new line that is to be built from Mingo to Steubenville by the Wheeling & Steubenville Traction Company will be only about one-fourth the length of the present line, and the time required for making the run between the two towns will thus be shortened from twenty-five minutes to a little more than six. The new road will be controlled chiefly by the stockholders of the Wheeling Traction Company.

WHEELING, W. VA.—The secretary of state has issued a charter to the West Virginia Interior Railroad Company. The company is capitalized at $100,000. Some of the promoters of this concern are said to be Wheeling capitalists. The company proposes to build a line from Steelton, the new town two and one-half miles north to New Martinsville, to extend south through the county seat of Wetzel, thence through Middlebourne, the county seat of Tyler, to Salem, Harrison County.

SPRINGFIELD, OHIO—The annual meeting of the stockholders of American Railways Company was held here recently. It was decided to erect a new power-house at a cost of $100,000. The officers elected are: Oscar T. Martin, president; H. J. Crawley, vice-president; C. L. S. Tingley, secretary and treasurer. Those elected to serve on the board of directors are: J. J. Sullivan, H. J. Crawley, C. L. S. Tingley, S. W. Pettit and John S. Bioren, of Philadelphia, Pa., and John H. Miller, Oscar T. Martin, I. Ward Frey, Charles L. Bauer, William F. Foos and Theodore Troupe, of this city.

ALTON, ILL.—The work of making the survey for the new electric line of the Central Traction Company, of Jerseyville, has been commenced. The line will be built to North Alton from Jerseyville and will also extend to Hardin, in Calhoun County. The route to be surveyed will run west from Jerseyville to Fieldon, thence to McClusky and Dow and Newburn, and thence to Godfrey and North Alton. From Fieldon the line will be built to Hardin, in Calhoun County. The entire route to be traversed will be about forty miles. June M. Rhoads and Robert Curdie, of Alton, are interested in the company.

SYRACUSE, N. Y.—Plans have been completed by the Rochester, Syracuse & Eastern railroad for the largest bridge ever built in the state by a traction company. It will be across the Montezuma marshes and will cost approximately $125,000. The structure will consist of twenty-five spans and will be 1,400 feet long. The abutments will be constructed entirely of concrete and the arches and girders will be of steel. The principal difficulty in the construction of the bridge will be finding a solid foundation in the marshes for the abutments. Another big steel bridge will be built by the Rochester & Eastern at Brighton. It will be of steel and concrete construction and 700 feet long. The work of grading for the
three divisions of the road is progressing rapidly, and substanti
progress will have been made before the cold weather.

YOUNGSTOWN, OHIO—Ravenna men have received blue pri
of the proposed Cleveland, Canton & Dover electric railroad, w
main lines between Cleveland and Canal Dover, an approximate
tance of eighty-six miles, and between New Baltimore and Allia
via Marlboro, ten miles. The route from Cleveland *via* Newbu
Corlett, Randall, Solon, Geauga lake, Aurora, Mantua, south
Shalersville, Ravenna, Rootstown, Randolph, New Baltimore, Har
ville, Middlebranch, Oval City, Canton, North Industry, Howen
Sparta, Sandville, Zoar, to Canal Dover and main line fork fr
New Baltimore to Alliance. Branches are also projected fr
Mantua to Warren, twenty-three miles, *via* Hiram, Garretsvi
Mahoning, Phalanx and Leavittsburg; from Sparta to Bay
eighteen miles, *via* Waynesburg, Malvern and Oneida; from One
to Carrollton, ten miles; from Zoar to Bolivar, four miles; fr
Zoar to Mineral City, three miles. The enterprise is under
motion of J. V. Ward, of Cleveland, who represents London
other English capital.

ENGINEERING SOCIETIES.

ENGINEERS' SOCIETY OF WESTERN PENNSYLVANI
The July issue of the proceedings of the Engineers' Society
Western Pennsylvania has been received. The paper in this is
of particular interest to electrical engineers is that by Clare
Renshaw, entitled "Present Electric Railway Practice." The o
articles are, "Safeguards in Bituminous Coal Mining," by W.
Fohl, and "Inertia in Gas and Steam Engines," by A. T. Kasle

THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEE
in its Transactions for September includes, besides reports of
meetings of the various branches, the report of the committee on hi
tension transmission. This committee, appointed in pursuance
a resolution adopted on September 26, 1902, collected data
present practice in electric transmission of high voltages. Co
of questions covering the desired data were mailed to engine
connected with and operating plants, and the replies were u
in formulating the report. Besides the answers to questions,
number of illustrations are given.

PHILADELPHIA SECTION OF THE AMERICAN INSTITU
OF ELECTRICAL ENGINEERS—The first meeting of the cou
of the Philadelphia section of the American Institute of Electri
Engineers was held on September 27. It was decided to ho
first regular branch meeting on Monday, October 10. A
time papers will be read on the telautograph and wireless te
raphy, illustrated by apparatus. The present officers of the bra
are: chairman, H. A. Foster; secretary-treasurer, H. F. Sanvi
managers, J. F. Stevens, A. J. Rowland, W. C. L. Eglin, C.
Pike, Paul Spencer and P. A. Spalding.

PHILADELPHIA SECTION, AMERICAN ELECTROCHEMIC
SOCIETY—The first regular meeting of the Philadelphia sec
of the American Electrochemical Society for the season of 190
was held at the Engineers' Club, 1122 Girard street, Ph
delphia, at 8 P. M., Friday, October 7, 1904. No programme
papers had been arranged for this meeting as the committee wan
to get the expression of opinion of members as to the best p
for the winter, it being thought that it would not be desirable
have meetings at which papers would be read each month, but ha
alternate meetings of more informal character.

PENNSYLVANIA STATE COLLEGE, BRANCH OF T
AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS—T
first joint meeting of the State College Branch of the American In
tute of Electrical Engineers and the Electrical Society of Penns
vania State College was held on Wednesday evening, Septem
28. Local officers of the society were elected from the membe
of the senior class, as follows: president, G. L. Christman; fir
vice-president, W. M. Seguine; second vice-president, C. E. Gov
secretary, H. L. Frederick; marshal, W. E. Kaiser; social co
mittee, C. L. Eshleman, T. H. Arnold and C. A. Bennett. Af
the election of officers there was a short informal discussion of
vices for axle-lighting systems on trains. There were about twen
five members present. Meetings will be held regularly ev
Wednesday evening during the school year.

TELEPHONE AND TELEGRAPH.

SEATTLE, WASH.—The Gaelic Consolidated Mines Company is completing arrangements for the construction of a telephone line from Merlin to Gaelic.

LORAIN, OHIO—The city council has granted a franchise to the Ohio Telephone and Telegraph Company to operate telephone and telegraph lines in this city.

DODGE CITY, KAN.—A new telephone franchise has been granted to L. J. Pettijohn and others to erect a telephone line. Work will be commenced immediately and completed in a year.

ROSSLAND, B. C.—The Nelson & Vernon Telephone Company is making extensive improvements to its plant in this city. The British Columbia Telephone Company is also reconstructing its system.

LITCHFIELD, ILL.—The People's Mutual Telephone Company has elected Robert P. Barnard, of Nokomis; G. D. Taylor, of this city, and C. H. Pollan, of Witt, members of the board of directors.

OCEAN PARK, CAL.—The city trustees have granted to the Home Telephone Company a permit to operate within the municipality. The company declares its intention of expending $90,000 in improvements.

CUYAHOGA FALLS, OHIO—The United States Telephone Company has begun the construction of new toll lines at Columbus and Medina. The company will shortly begin a new line between Ravenna and Alliance.

BAKER CITY, ORE.—The Pacific States Telephone Company is preparing to make many improvements in its plant in this city. A new multiple switchboard will be installed. The company is also constructing a line to the Iron Dyke mines, on Snake river.

SMITHBORO, N. Y.—The Ross Hill-Smithboro Telephone Company has been organized to install a local system. The directors are: Eugene A. Hussong, Charles E. Carpenter, Charles M. Bedell, Eugene E. Bailey, James J. Loveless, Smith A. Williams and George Eiklor.

SEATTLE, WASH.—The Rocky Mountain Telephone Company states that construction will soon be started on a line into the Thunder mountain district. A branch into the Big Creek section will leave the main line on Johnson creek and cross Profile Gap into Big Creek flat.

NORTHFIELD, VT.—The telephone system owned by the Warren Telephone Company has been purchased by W. B. Jones and L. H. McAllister, of Waitsfield, and turned over by them to the New England Telephone and Telegraph Company. This line extends from Middlesex into the towns of Moretown, Waitsfield, Roxbury, Warren and Lincoln.

COLUMBUS, OHIO—The Franklin County Telephone Company is arranging to make a number of improvements in its service outside of Columbus and will attempt to place a telephone in almost every farmhouse. At the annual meeting of the company a bond issue of $100,000 was authorized and if the money is needed for the proposed improvements the issue will be placed on the market.

WOONSOCKET, R. I.—At a meeting of the board of directors of the Providence Telephone Company, which controls the Woonsocket telephone system, held in Providence, it was voted to increase the capital stock of the corporation by $400,000. The present capitalization is $1,600,000. The additional capital will be used in taking up the present indebtedness of the company and in paying for extensive improvements now under way or contemplated for the immediate future.

LINCOLN, NEB.—The independent companies of Garfield County have merged and filed articles of incorporation with the secretary of state. Burwell is to be the headquarters of the new system. The Garfield Mutual Telephone Company is the name of the organization. A. V. Cronk is named in the articles as the president and general solicitor of the association. D. S. Gilbert is vice-president, Freeman Freeland is the secretary and James F. Groatley, treasurer. The parties to the agreement are the Calamus Mutual, the Rose Hill Mutual, the Willow Springs Mutual, the North Side Mutuals, the East End Mutual and the Rockford Mutual. A feature is the absence of any capital stock, the companies being purely mutual for the benefit of the members of the various consolidating companies.

ELECTRICAL SECURITIES.

An averaging of prices, in general, for the week closing October 1 will show a condition approximating the highest price level for the year. This, taking into consideration the fluctuations which have marked the last two or three weeks, with the positive decline of the week previous, proves that the market is possessed of great inherent stability, and that the bull movement is strongly intrenched and not wanting in large financial backing. Railroad earnings reported during the week have been irregular, showing, on the whole, encouraging progress, but not carrying out the predictions spread broadcast by the bull manipulators of the present campaign. The feature of most significance is the increase in gross returns. The earnings reported by coal roads have been unsatisfactory, these reflecting the depression that still exists in the fuel industry. The iron and steel trade, the textile industries and the manufacturing trades generally have not rallied as much as was expected several weeks ago. There is in evidence, however, considerable promise of renewed activity in industrial lines in general, and if the revival has not been able to keep pace with the rapid increase in the price of stocks, it has, at least, been steady.

ELECTRICAL SECURITIES FOR THE WEEK ENDING OCTOBER 1.

New York:	*Closing.*
Brooklyn Rapid Transit	57⅜
Consolidated Gas	212¼
General Electric	173½
Interborough Rapid Transit	148½
Kings County Electric	185
Manhattan Elevated	153⅜
Metropolitan Street Railway	121½
New York & New Jersey Telephone	157
Westinghouse Manufacturing Company	190

The annual meeting of the stockholders of the Manhattan Railway Company will be held in New York city, November 9. Books close October 8 and reopen November 10.

The New York & New Jersey Telephone Company has declared a regular quarterly dividend of 1½ per cent, payable October 15.

The condensed balance sheet of the Kings County Electric Light and Power Company, as of June 30, 1904, shows assets of $12,395,002, and liabilities of $11,536,542, leaving a surplus of $858,460. The stock exchange has listed for the company $483,000 additional capital stock, making a total listed of $5,000,000.

Boston:	*Closing.*
American Telephone and Telegraph	139¼
Edison Electric Illuminating	257½
Massachusetts Electric	57¼
New England Telephone	129½
Western Telephone and Telegraph preferred	90

At the last regular monthly meeting of the Massachusetts Electric Companies it was announced that the net earnings of the companies for eleven months and the gross earnings for September show an amount equal to about 2 per cent on the preferred shares, which was paid July 1 last. The loss in net income is said to be due solely to the severe winter, as the gross and net of the companies for the first and last three months of the year show about the same as the normal of the previous three or four years.

Philadelphia:	*Closing.*
Electric Company of America	9⅝
Electric Storage Battery common	66
Electric Storage Battery preferred	66
Philadelphia Electric	7
Union Traction	55⅞
United Gas Improvement	97

Chicago:	*Closing.*
Chicago Telephone	122
Chicago Edison Light	152½
Metropolitan Elevated preferred	62
National Carbon common	32
National Carbon preferred	107
Union Traction common	7¼
Union Traction preferred	33

The statement of the South Side Elevated Company for the year ended June 30, 1904, is as follows: gross $1,690,842; expenses, $948,098; net, $742,744; other income, $10,167, a total of $752,911; charges, $173,295, and dividends, $412,952, leaving a surplus of $166,664, as compared with $134,693 for 1903.

INDUSTRIAL ITEMS.

ROYLE & AKIN, manufacturers of magnet wire and fine wires for electrical purposes, have moved their factory from Newark, N. J., to Ossining, N. Y.

THE BATTERIES SUPPLY COMPANY, Newark, N. J., manufacturers of the Gladstone-Lalande battery, has issued a catalogue completely descriptive of this battery, with illustrations and prices.

THE THRESHER ELECTRIC COMPANY, of Dayton, Ohio, supplied the electric deck winches, six in all, for the new battleship Connecticut, which was launched on Thursday of last week, and also the motor-generators for controlling the turrets.

PFAELZER, WALKER & COMPANY, bankers, 16 State street, Boston, Mass., are publishing a list of quotations for the bonds of 600 street railway companies. The company's New York office is at 25 Broad street, and the Philadelphia office is at 433 Chestnut street.

THE HUNTER ILLUMINATED CAR SIGN COMPANY, Cincinnati, Ohio, manufacturers of a very effective form of illuminated car signs and fenders, has distributed its annual convention souvenir by mail. All the cars of the New York subway will be equipped with Hunter signs.

THE NERNST LAMP COMPANY, Pittsburg, Pa., has issued catalogue No. 2, which supersedes all previous price lists for Nernst lamps and parts. The catalogue, besides giving the good points of the Nernst lamp, shows a number of pictures of the factory, of places lighted by the lamps and of lamp fixtures.

THE GENERAL INCANDESCENT ARC LIGHT COMPANY, 529 West Thirty-fourth street, New York city, has been awarded a contract for 1,250 "G. I." dust and water-tight floor outlet boxes for the new John Wanamaker building at Philadelphia, Pa. This order comes through the Pennsylvania Electrical Equipment Company.

THE CANADIAN WESTINGHOUSE COMPANY, LIMITED, Hamilton, Canada, has opened offices in Winnipeg, Manitoba. These offices are located in the Union Bank Building. The representative in charge of the district covered by this office is Mr. W. E. Skinner, who was formerly associated with the Westinghouse Electric and Manufacturing Company, Pittsburg, Pa.

THE ELECTRIC CONTROLLER AND SUPPLY COMPANY, Cleveland, Ohio, desires to announce the opening of a southern branch office at 509-510 Woodward Building, Birmingham, Ala. This company is now represented in the following cities: New York, Philadelphia, Pa., Pittsburg, Pa., Cleveland, Ohio, Birmingham, Ala., Denver, Col., San Francisco, Cal., and London, England.

THE AMERICAN ELECTRIC TELEPHONE COMPANY, 36 West Jackson Boulevard, Chicago, Ill., has recently supplied the United States government with switchboard exchange equipments in twelve separate divisions. Six switchboards were sent to different points in Virginia: one switchboard to Wyoming, one to New York, three switchboards to different points in California, and one switchboard to the District of Columbia.

THE COOLEY GENERAL DEVELOPMENT COMPANY, Jamaica Plain, Boston, Mass., has produced an engine which they claim is "fool proof." One of the types of engines made measures but 3.5 inches by 2.5 inches, weighs four pounds and at 2,000 revolutions per minute, and 200 pounds initial steam pressure, develops 1.5 horsepower. It is being used successfully for direct-connection to small machines. In addition, the company makes a number of larger types.

THE ELECTRIC MOTOR AND EQUIPMENT COMPANY, Newark, N. J., has perfected and is now placing on the market a new commutating switch, designated as the "Jem Flasher." This switch is claimed to possess a number of improvements, among which is the valuable feature of interchangeability. By the use of a screw driver, certain arms, mounted on a revolving shaft, can be easily adjusted so that almost any relation of make and break of each circuit can be effected.

THE R. D. NUTTALL COMPANY, Pittsburg, Pa., is publishing a neat cloth-bound book entitled "Nuttall Gearing." It takes up the various kinds of gears, rack and pinion, illustrates sizes of gear teeth and gives a list of gear formulæ. Rules for pitch diameters, calculating speeds and valuable dimensions and data are included. In the back of the book are inserted a number of pages for additions and memoranda. This book, the price of which is one dollar, was presented to the participants of the circular tour on their visit to Pittsburg.

THE MANHATTAN TRANSIT COMPANY, 250 East Forty-eighth street, New York city, has announced that its policy will be to purchase vehicles, rather than to manufacture them at its own plant. With this end in view, specifications and blue prints for electric omnibuses to carry, say, twenty-four passengers (inside only) are invited. No original papers should be submitted, as the company will not be responsible for the return of any papers. Communications in reference to this should be addressed to the mechanical director, Mr. Charles A. Lieb, at the above address.

MESSRS. HALL & HENSHAW, fire underwriters, 35 Pine street, New York city, are representing a strong line of fire insurance companies, with headquarters in various large cities in the United States. This company is the United States manager for the Union Assurance Society, of London; the Law Union and Crown Insurance Company, of London; the State Fire Insurance Company, Limited, of Liverpool, and the Victoria Fire Insurance Company, of New York. All forms of risks are taken, including automobile liability, employers' liability and common carrier liability. The members of the company are Henry H. Hall, William W. Henshaw, Edward K. Beddall and Warren F. Goodwin. The Chicago office of the company is at 171 La Salle street.

THE CENTRAL ELECTRIC COMPANY, Chicago, Ill., has issued a handsome catalogue devoted entirely to its lighting fixture department. The book is nine inches by twelve inches, and contains eighty pages of descriptive matter concerning fixtures, portables, glassware and trimmings. The arrangement and class of goods shown will be sure to attract attention. The Central Electric Company has facilities for handling this trade, as a competent fixture man is in charge of this branch of the business. In addition to this, there is a special fixture display room which has been fitted up with a line of samples giving a wide selection for a prospective buyer. The company has recently placed on the market a new portable and desk lamp. Any central station manager or dealer who has not already received a copy of this catalogue will receive one by addressing the company.

THE AMERICAN DISTRICT STEAM COMPANY, Lockport, N. Y., has recently finished two large steam-heating installations in Detroit, Mich. One of these installations is for the Central Heating Company, and the other was put in for L. J. Murphy. The installation of the Central Heating Company will have approximately four miles of pipe, and the Murphy installation about two miles. This company has also recently put in an elaborate installation in St. Paul with four miles of steam pipe and this installation goes into the business portion of the city. An installation put in by this company at Easton, Pa., for the Easton Steam Heating Company, has a two-mile system; the company has also made an extensive addition to the system which has been in operation at Baltimore, Md. At Cheyenne, Wyo., a plant with a mile and a half of steam piping has been installed. In addition to those mentioned, the company has put in many smaller ones during the past season.

THE NATIONAL ELECTRIC COMPANY, Milwaukee, Wis., and the Hooven, Owens, Rentschler Company, Hamilton, Ohio, offer an opportunity to purchase their exhibit at block 46, Machinery Building, Louisiana Purchase Exposition. This unit consists of a National revolving-field alternator, of 1,500-kilowatt capacity, direct-connected to the new Hamilton Corliss vertical, cross-compound, condensing engine, running at eighty-three revolutions per minute. The entire equipment represents the latest developments of engineering design, and may be seen in operation until the close of the exposition. A detailed description of this exhibit, with illustrations, will be mailed upon request, or the representatives of the above firms may be found at block 46, Machinery Building. The National Electric Company is also located at section 6, Electricity Building, where a number of other direct and alternating-current units of smaller capacity are to be disposed of. It is announced that the above-mentioned engine has been awarded a gold medal.